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for

Army Air Corps

PHOTOGRAPHIC OBSERVATIONS OF BLADE MOTION OF THE YG-1B AUTOGIRO EQUIPPED WITH TAPERED ROTOR BLADES

By F. J. BAILEY, JR. and W. B. BOOTHBY

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May 9, 1940

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PHOTOGRAPHIC OBSERVATIONS OF BLADE MOTION OF THE YG-1B AUTOGIRO EQUIPPED WITH TAPERED ROTOR BLADES

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SUMMARY

This report presents the results of photographic observations in flight of the flapping, the motion about the vertical pin, and the dynamic twist of a new type tapered rotor blade on the Kellett YG-1B autogiro. The blades, which were designed by the Kellett Autogiro Corporation, made use of the N.A.C.A. 230 series airfoil section, for the purpose of eliminating undesirable dynamic blade twist present in the original blades. The results reported herein show that in actual operation the new blades very closely approach the desired condition of no dynamic twist.

INTRODUCTION

Photographic observations of the blades of autogiro rotors in flight have shown that the flapping motion of a rotor blade is ordinarily accompanied by a periodic twisting of the blade about its longitudinal axis. It has been shown theoretically, (reference 1), and experimentally, (references 2 and 3) that this periodic twist has an important effect on the blade flapping motion. Full-scale tunnel tests of the original YG-1B rotor (reference 4) have demonstrated that periodic twist is also of primary importance insofar as the rotor center-of-pressure travel is concerned.

The corrective measure that has been applied in the past to reduce periodic twist consists in attaching a small reflexed tab along the trailing edge of the outboard part of the rotor blades. As a temporary expedient, for correction of unstable center-of-pressure travel in rotors already designed, this procedure has proven fairly satisfactory. Ordinarily, however, it does not completely eliminate periodic twist. Furthermore, the rotor is extremely sensitive to the tab adjustment and, in at least one case, severe vibration in the autogiro was traced to an almost unnoticeable warping of the tab on one blade. It appears certain that future rotors,

incorporating either feathering control or controllable pitch for jump take-off or helicopter flight, will require more complete suppression of periodic twist than is feasible with tabs, to avoid large periodic loads in the pitch-changing mechanism.

A theoretical study of the factors responsible for the periodic blade twist (reference 5) has indicated that, in the case of new designs, the twist can be eliminated without the use of tabs provided: (1) the airfoil section chosen for the blades has a moment coefficient of zero about the aerodynamic center; and (2) the blades are so designed that the line of aerodynamic centers of the elements, the line of centers of gravity of the elements, and the elastic axis of the blade all coincide in a single radial line.

Recently the Kellett Autogiro Corporation has designed a set of blades, for use on the YG-1B autogiro, that fulfill, as far as practical, the above requirements. In this new design, which incorporates a slight taper in both plan form and thickness, the requirement of zero moment coefficient about the aerodynamic center is satisfied, without an appreciable loss in performance, by the use of airfoil sections of the N.A.C.A. 230 series. The new blades were tested in flight by the National Advisory

Committee for Aeronautics at Langley Field, Virginia, during November and December of 1939. Previous reports (references 6 and 7) have shown that substitution of the new blades for the old reduces the control-stick vibration and makes the rotor center-of-pressure travel more stable.

The present report covers flight observations of the flapping, vertical pin motion, and twist of the new blades. The results are of interest primarily as experimental verification of the theoretical conclusion that periodic blade twist can be controlled or eliminated by proper blade design. They are also expected to prove useful in connection with future theoretical work on rotor center-of-pressure travel.

APPARATUS AND TESTS

The Kellett YG-1B (fig. 1) is a three-blade, direct-control, autogiro weighing, fully loaded, 2,269 pounds. It is powered by a Jacobs R-755-3 engine rated at 225 horsepower. The original rotor blades (fig. 2) which were rectangular in plan form and uniform in thickness had a radius of 20 feet and a chord of 12 inches. The Göttingen 606 airfoil section used in these blades was modified by a reflexed trailing edge tab that extended the blade chord one inch over the portion of blade between 72.1 percent and 93.2 percent of the blade radius.

The new blades are also of 20-foot radius. They employ airfoil sections of the N.A.C.A. 230 series, varying in thickness from 16 percent with a 15-inch chord at the root to 10 percent with a 12-inch chord at the tip. The taper in both plan form and thickness is linear. Along the entire trailing edge of the blade the last 1-1/4 inch of the chord is reflexed 0.86° in an attempt to reduce to zero the small negative moment coefficient of the 230 sections.

The new blades are 9.2 pounds heavier apiece than the original blades. The fully loaded weight of the machine with the new blades is therefore 2,297 pounds. During the present tests the observer was omitted and approximately 50 pounds of recording instruments were added. The pilot was approximately 20 pounds lighter than the 200 pounds on which the gross weight figure was based. Hence, the weight at take-off in the present tests is estimated as 2,127 pounds.

The motion of the blades relative to the rotor hub was recorded by means of a motion-picture camera mounted on the hub and aimed radially outward along one of the three blades. The camera turned with the hub. The azimuth position of its optical axis at the instant each picture was exposed was established by means of

a timing light incorporated in the camera. A solenoid, operated by a make-and-break contact ring, caused the image of this light on the film to change position abruptly at six specified azimuth positions of the rotor.

The camera was focused on a pair of small aluminum targets, one extending forward from the blade leading edge, and the other extending aft from the trailing edge. These targets were located at the three-fourths radius station, hence the twist, flapping, and vertical pin motion reported herein are based on the motion of the blade element at that point.

In addition to the camera records of the blade motion, simultaneous records of the rotor speed, air speed, and control position were obtained with N.A.C.A. recording instruments.

The tests made can be divided into three groups. The first group includes tests intended to establish the periodic blade twist, the blade flapping, and the motion of the blade about the vertical pin, in steady flight. These tests covered a range of indicated air speeds from 40 to 100 miles per hour in both steady level flight and steady glides.

The second group of tests involved observations of the blade motion, control position, air speed, and rotor speed during a number of simple maneuvers at air

speeds of 70 miles per hour or lower. These maneuvers included a take-off, right and left banks, push-downs, and mild pull-ups. The purpose of this group of tests was to determine the extent to which abnormal blade motion might be induced by manipulation of the control or by accelerations imposed on the autogiro.

When an autogiro is on the ground with its rotor turning, the elastic response of the pylon and landing gear to unbalance in the spinning rotor occasionally causes the machine to rock laterally or longitudinally at certain rotor speeds. Although the oscillation does not ordinarily attain a dangerous amplitude because of the damping action of the landing-gear shock struts, it was felt that observation of the vertical pin motion of the blades during such a condition might prove of general interest. For this reason a third series of tests included observations of the motion of the blades about the vertical pin while the autogiro was stationary on the ground. In these tests the records were taken while the engine was driving the rotor steadily, at a series of rotor speeds from 80 to 190 r.p.m.

RESULTS AND DISCUSSION

The results of the observations of the blade motion in steady flight are presented in figures 3 to 8, inclusive. Typical curves showing the observed variation of the twist angle θ at three-fourths radius, the flapping angle β, and the vertical pin angle ζ, are given in figures 3, 5, and 7, respectively, for one value of the tip-speed ratio, $\frac{V}{\Omega R}$.

Experience has shown that variations of the type observed can be very closely approximated by the following Fourier series:

$$\theta = \epsilon_0 + \epsilon_1 \cos \psi + \eta_1 \sin \psi + \epsilon_2 \cos 2\psi + \eta_2 \sin 2\psi$$

$$\beta = a_0 - a_1 \cos \psi - b_1 \sin \psi - a_2 \cos 2\psi - b_2 \sin 2\psi$$

$$\zeta = E_1 \cos \psi + F_1 \sin \psi + E_2 \cos 2\psi + F_2 \sin 2\psi$$

Values of the coefficients in these expressions, determined by harmonic analysis of curves similar to those shown in figures 3, 5, and 7, are plotted as functions of the tip-speed ratio in figures 4, 6, and 8.

Comparison of the coefficients given in figures 4, 6, and 8 with similar coefficients for the original blades given in figures 6, 2, and 4 of reference 3 shows that the twist that characterizes the original blades has been virtually eliminated by the change in blade

design. The reduction of blade twist, coupled with the effect of taper on the radial location of the blade center of pressure relative to the center of percussion, is apparently responsible for a reduction in the coning angle a_0, an increase in the rate of change with tip-speed ratio of the longitudinal flapping coefficient a_1, and a reduction in the second harmonic flapping coefficients a_2 and b_2.

The results of the observations of the blade motion during maneuvers are presented in the form of histories of the flapping angle, β, the vertical pin angle, δ, the rotor speed, the tip-speed ratio, and the control position during each maneuver. The angles β and δ were recorded as functions of the azimuth position of the rotor, while the other quantities were recorded as functions of the time in seconds. For this reason exact synchronization of the blade motion with the other records is not feasible. Approximate synchronization is possible, however, since both types of record start and terminate simultaneously.

The twist angle θ is not included in the data presented for the various maneuvers because examination of the records revealed that it never exceeded the small values observed in steady flight.

The departure of the mean value of the vertical pin angle ζ from zero in figures 10, 12, 14, 15, 16, and 19 should be ignored. In the flight during which these records were made no usable picture of the blade at rest was obtained, hence it was impossible to correct for the departure of the azimuth position of the camera optical axis from the position in which the original calibration was made. This correction is ordinarily necessary, because the camera is removed from the machine for reloading between flights.

The damped oscillation appearing on the record of rotor speed in the take-off (fig. 9a) is believed to be an oscillation in the shaft of the recording tachometer induced by the abrupt release of the rotor clutch.

Examination of the time histories of the various maneuvers reveals that in general the blade motion at any instant corresponds closely to that at the same tip-speed ratio in steady flight. Abrupt displacement of the controls causes a noticeable change in the flapping and vertical pin motion, but the irregularity is of short duration. It seldom persists for more than a revolution of the rotor. In pull-ups the sudden increase in angle of attack of the rotor apparently causes some increase in coning angle, which persists while the rotor speed is increasing.

The results of the observations of vertical pin motion during steady engine-driven runs on the ground are summarized in figures 10 and 11. Figure 10 shows a typical record of the variation of the angle at the vertical pin with the azimuth angle of the rotor blade. Four successive revolutions are plotted, each with a different symbol. The range of vertical pin angles covered at any one azimuth position is indicative of the extent to which the pattern of the blades varied during the four revolutions. As the rotor speed increased, both the amplitude of the vertical pin motion and the departure of successive revolutions from the mean, decreased rapidly. Severe rocking of the autogiro did not occur in any run.

Curves similar to that shown in figure 10 were obtained for a series of rotor speeds from 80 to 190 r.p.m. They can be very closely approximated by a series of the form

$$\zeta = E_0 + E_1 \cos \psi + F_1 \sin \psi$$

The experimentally determined coefficients E_0, E_1, and F_1 are shown in figure 11 as functions of the rotor speed. Also shown on figure 11 is the variation with rotor speed of the amplitude, $\sqrt{E_1^2 + F_1^2}$, of the vertical pin motion. It will be noted that vertical

pin motion of large amplitude is confined to very low rotor speeds.

CONCLUSIONS

1. Dynamic blade twist does not cause the pitch at the three-fourths radius of the new blades to depart from the static value by more than one-half of one degree. This maximum twist is approximately one-fifth of that found in the original blades.

2. Preliminary examination of the records of blade motion in maneuvers indicates that the control motion and the accelerations imposed on the autogiro do not induce any large or unexpected departure of the blade from its normal path.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., May 9, 1940.

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Approved:

Elton W. Miller,
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R.

REFERENCES

1. Wheatley, John B.: An Analytical and Experimental Study of the Effect of Periodic Blade Twist on the Thrust, Torque, and Flapping Motion of an Autogiro Rotor. T.R. No. 591, N.A.C.A., 1937.

2. Wheatley, John B.: Blade Motion and Bouncing Tests of KD-1 Autogiro. Conf. Memo. Report, N.A.C.A., June 13, 1935.

3. Wheatley, John B. and Bailey, F. J., jr.: Flight Tests of Blade Motions and Center-of-Pressure Location on Kellett YG-1B Autogiro. Conf. Memo. Report for Army Air Corps, N.A.C.A., July 7, 1937.

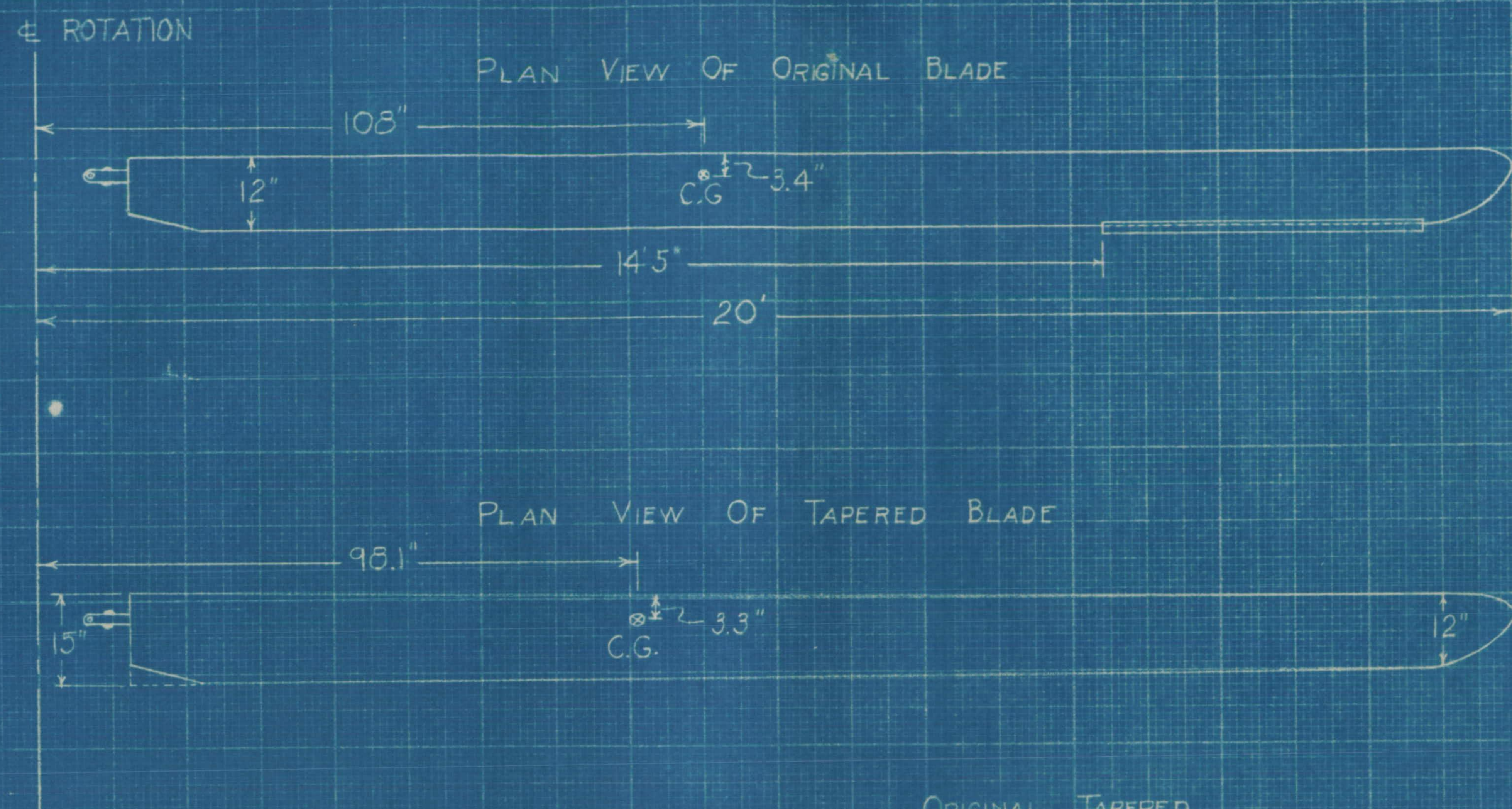
4. Wheatley, John B. and Clay, William C.: Full-Scale Wind Tunnel and Flight Tests of a YG-1 Autogiro. Conf. Memo. Report for Army Air Corps, N.A.C.A., Aug. 26, 1937.

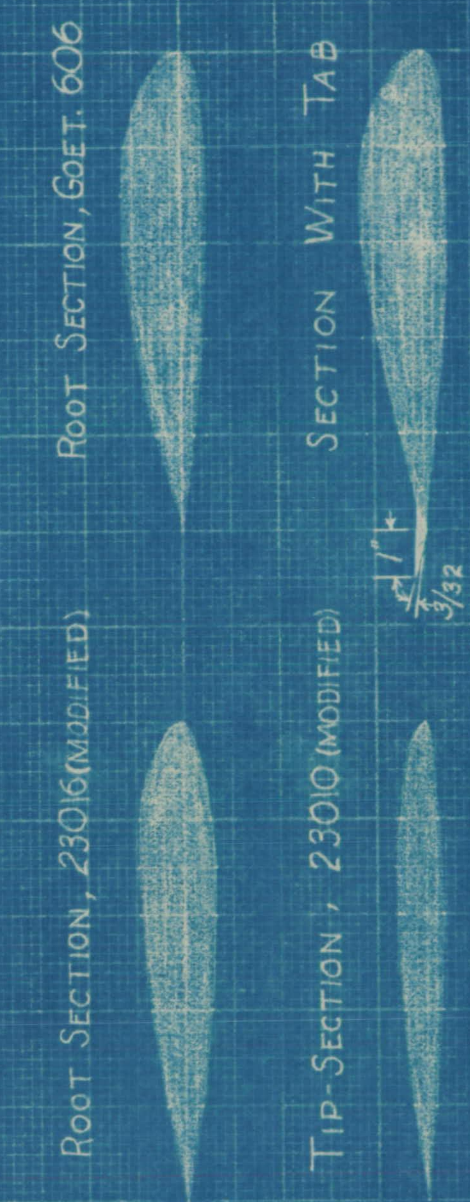
5. Wheatley, John B.: An Analysis of the Factors that Determine the Periodic Twist of an Autogiro Rotor Blade, with a Comparison of Predicted and Measured Results. T.R. No. 600, N.A.C.A., 1937.

6. Bailey, F. J., jr. and Gustafson, F. B.: Flight Measurements of Stick Vibration of the YG-1B Autogiro Equipped with Tapered Rotor Blades. Conf. Memo. Report for Army Air Corps, N.A.C.A., Feb. 28, 1940.

7. Bailey, F. J., jr.: A Flight Determination of the Moments of the YG-1B Tapered Blade Rotor about the Hub Trunnions. Conf. Memo. Report for Army Air Corps, N.A.C.A., Nov. 15, 1939.

Figure 1.- The YG-1B autogiro.





	ORIGINAL	TAPERED
WEIGHT OF BLADE OUTBOARD OF VERTICAL PIN	54.3 lbs.	63.5 lbs.
WEIGHT OF BLADE OUTBOARD OF HOROZONTIAL PIN	64.1 lbs.	73.3 lbs.
MOMENT OF INERTIA ABOUT VERTICAL PIN	155 slug/ft²	163 slug/ft²
MOMENT OF INERTIA ABOUT HOROZONTIAL PIN	175 slug/ft²	185 slug/ft²
BLADE PITCH SETTING	2°35'±5'	3°30'±5'

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Figure 2.- Comparison of original and new rotor blades - YG-1B autogiro.

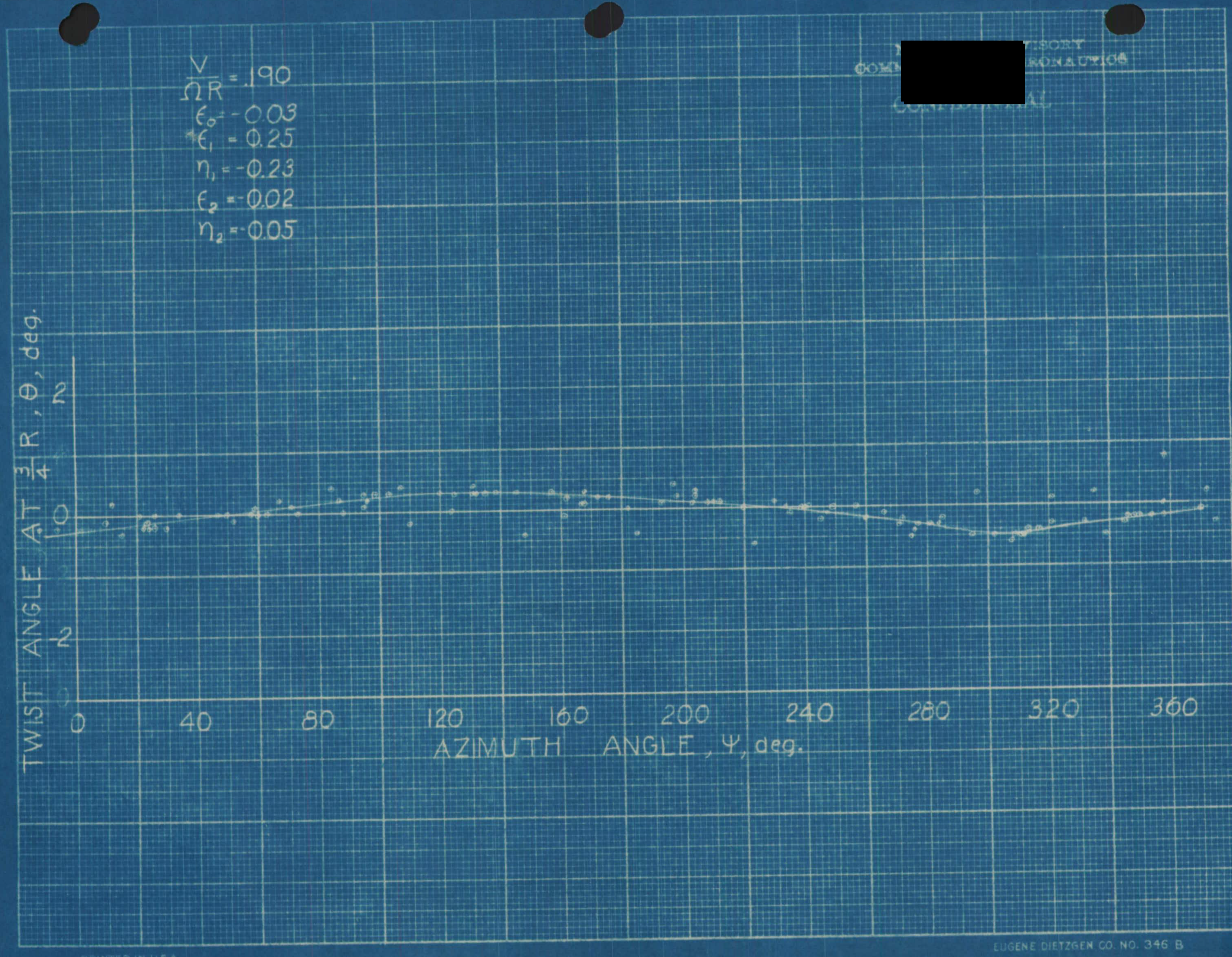

Figure 3.- Typical blade twist angle at three-fourths radius. YG-1B autogiro with tapered blades.

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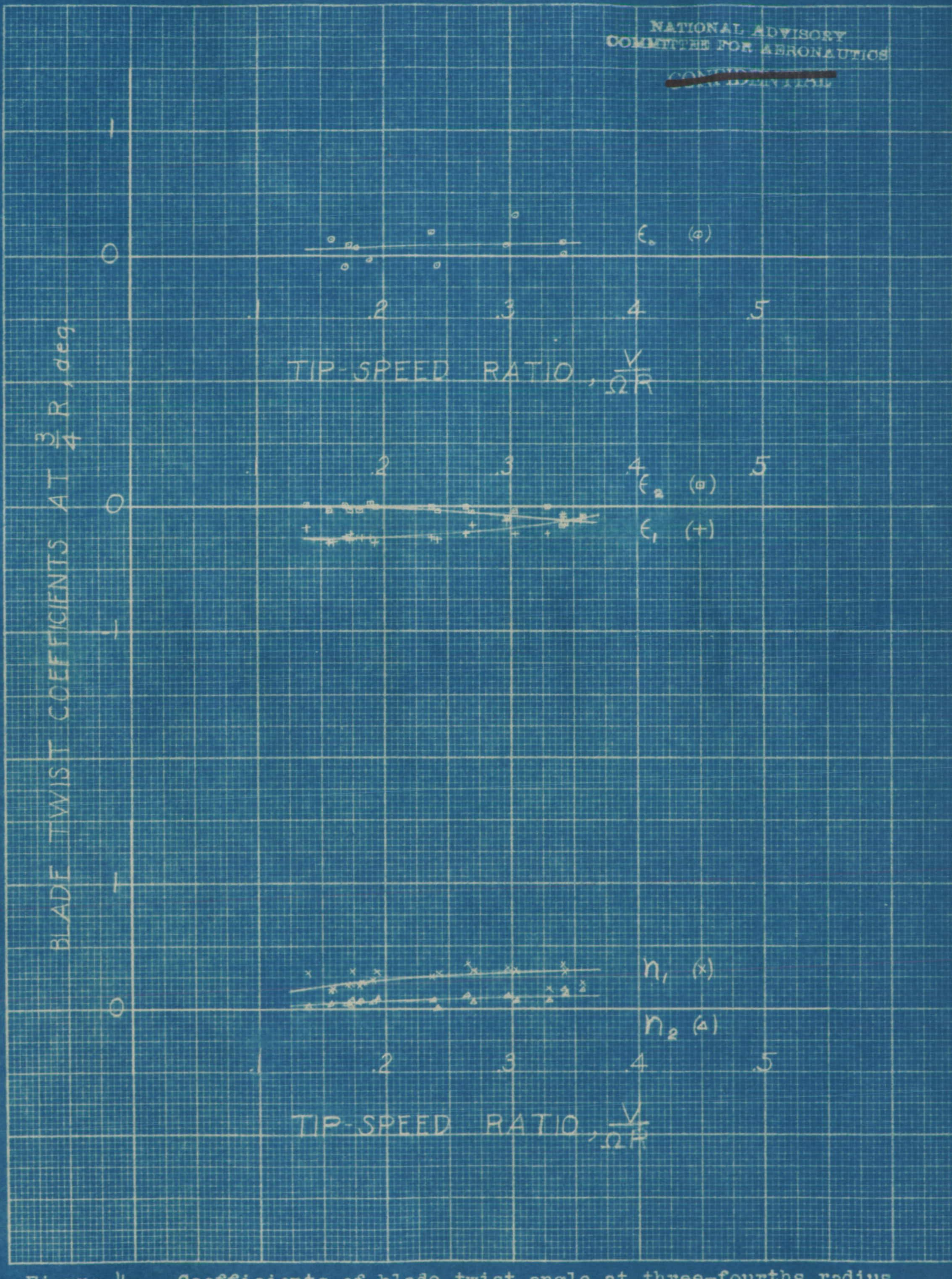

Figure 4.- Coefficients of blade twist angle at three-fourths radius. YG-1B autogiro with tapered blades.

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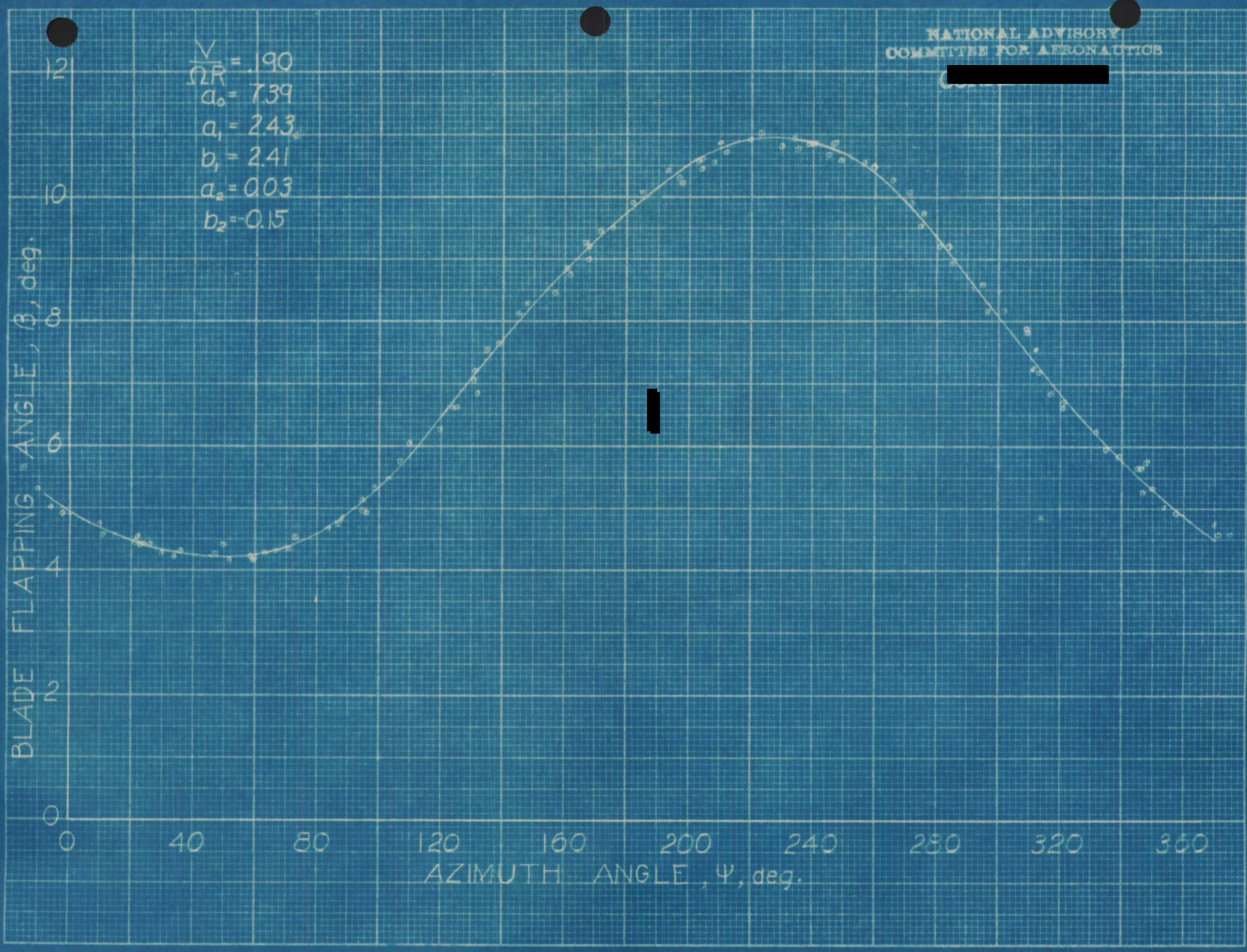

Figure 5.- Typical blade flapping motion. YG-1B autogiro with tapered blades.

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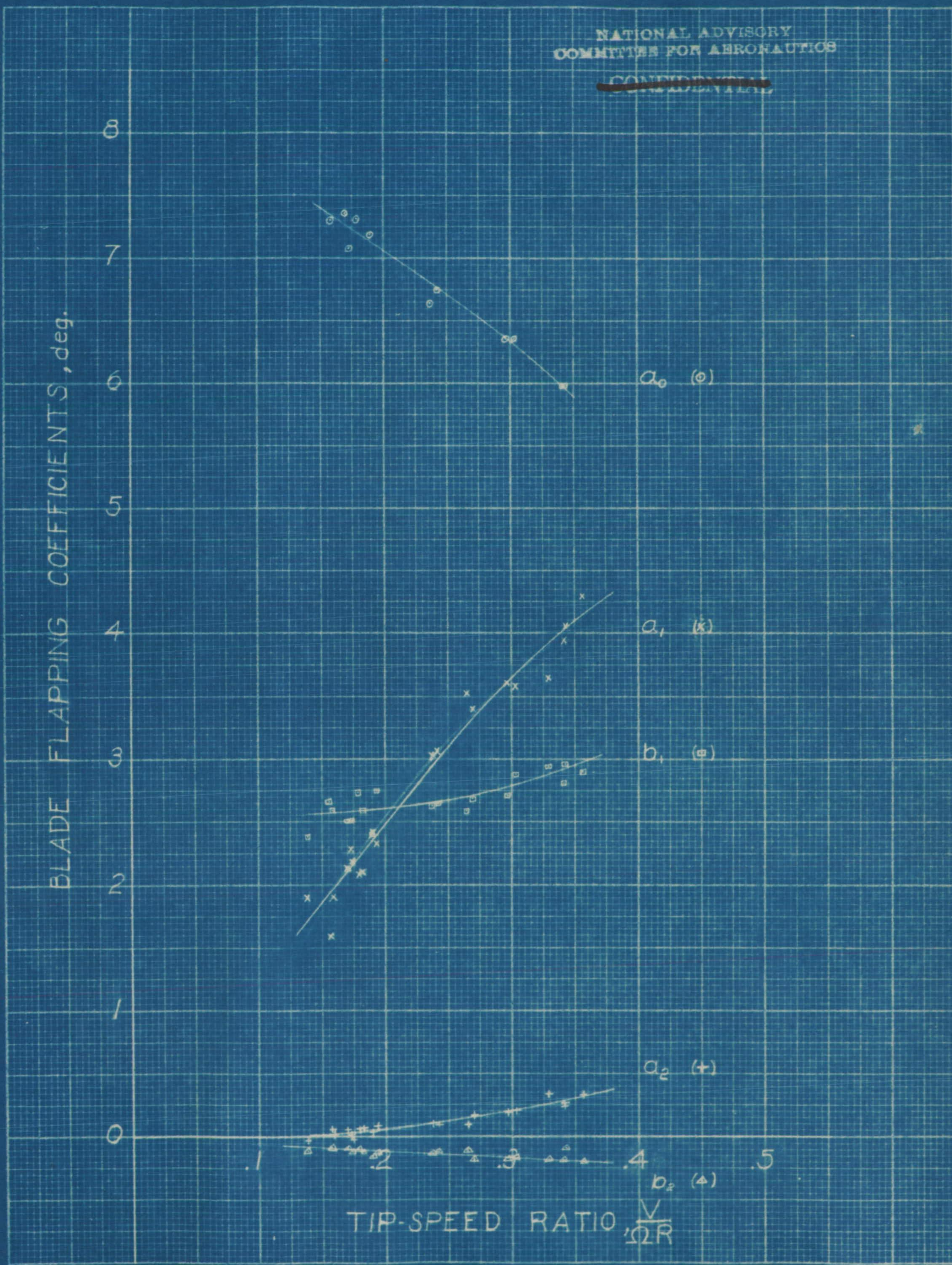

Figure 6.- Coefficients of blade flapping motion. YG-1B autogiro with tapered blades.

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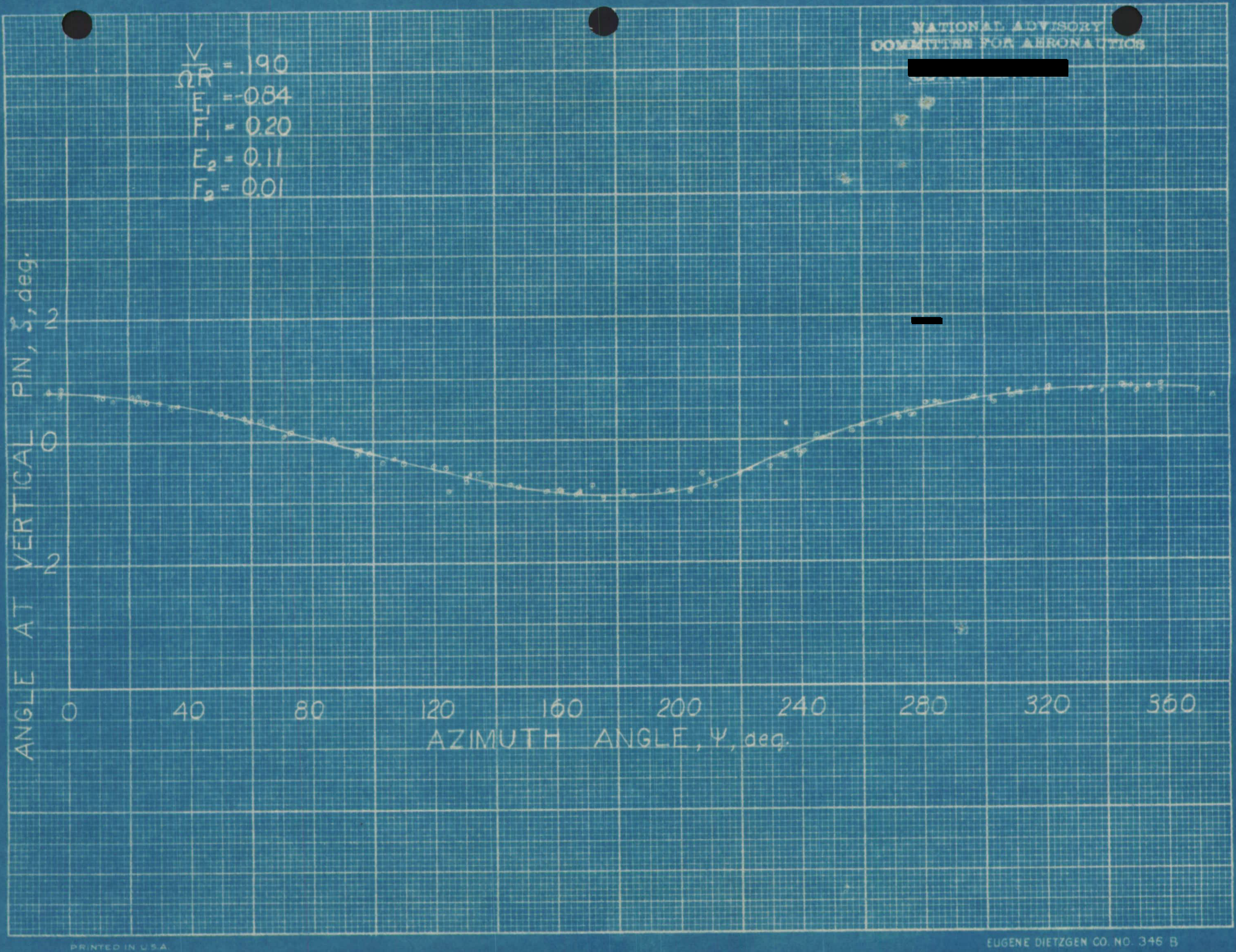

Figure 7.- Typical motion about vertical fin. YG-1B autogiro with tapered blades.

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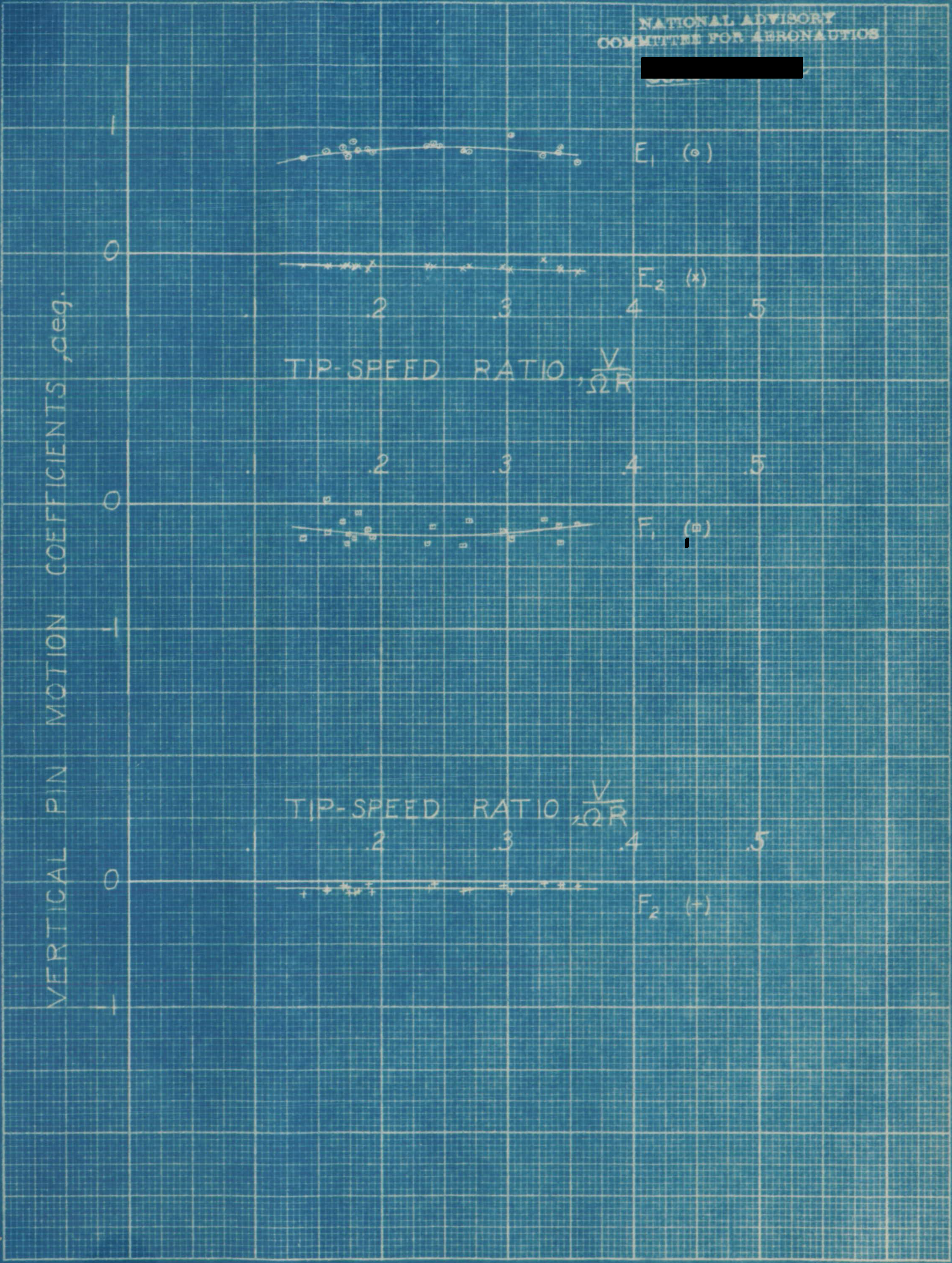

Figure 8.- Coefficients of motion about vertical fin. YG-1B autogiro with tapered blades.

8-1
Fig 9a

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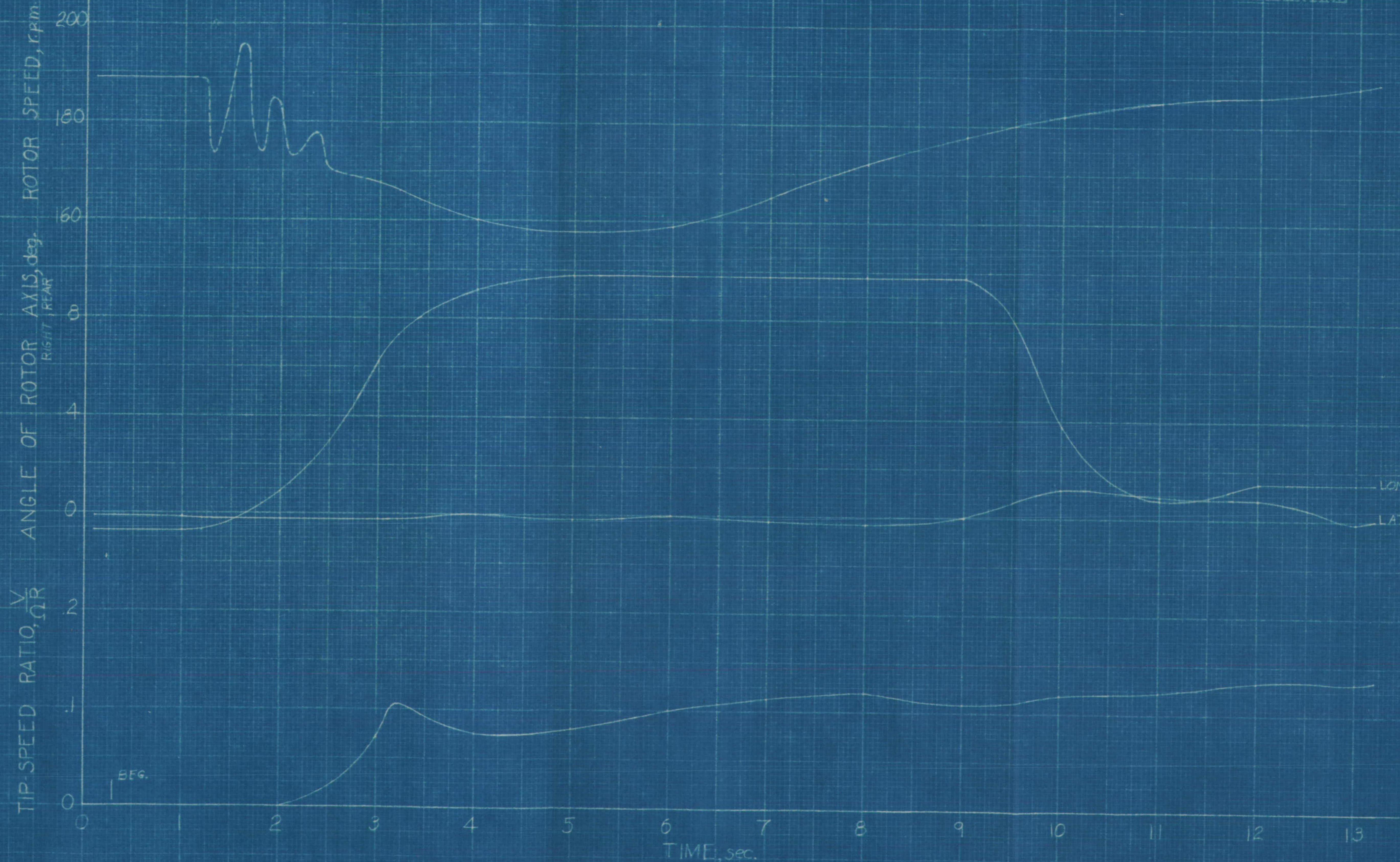

Figure 9a.- Time history of take-off. YG-1B autogiro with tapered blades.

8-1
Fig 9b

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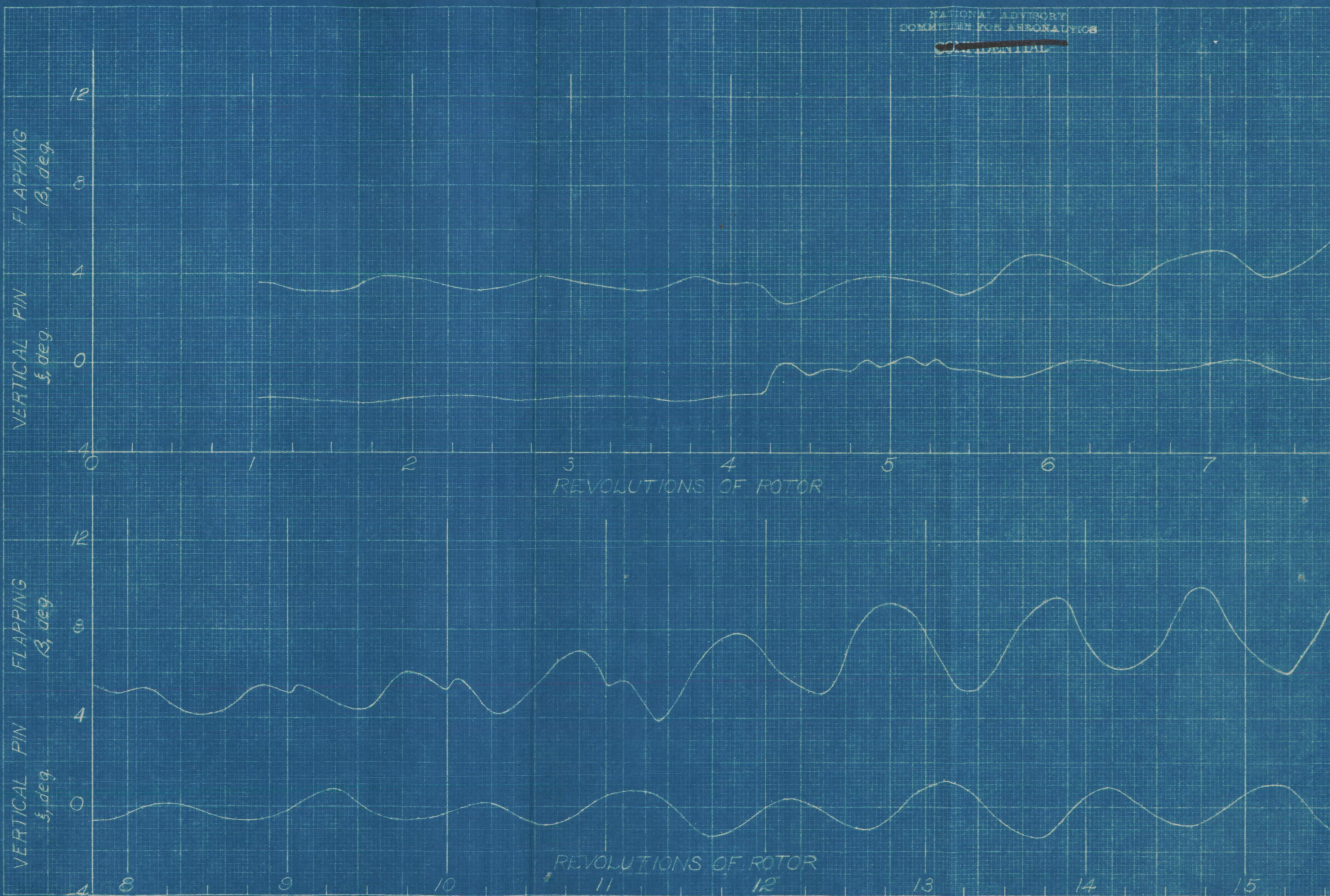

Figure 9b.- Time history of take-off. YG-1B autogiro with tapered blades.

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8-1
FIG 9c

Figure 9c.- Time history of take-off. YG-1B autogiro with tapered blades.

8-1
FIG. 9d

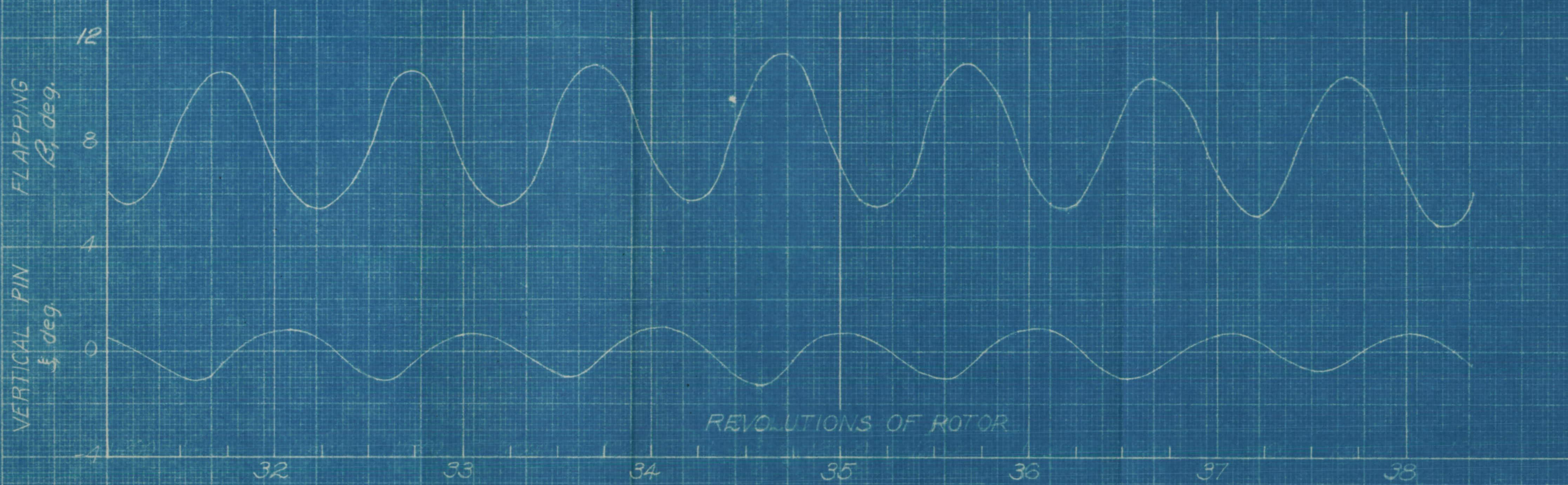

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Figure 9d.- Time history of take-off. YG-1B autogiro with tapered blades.

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7-1
Fig 10a

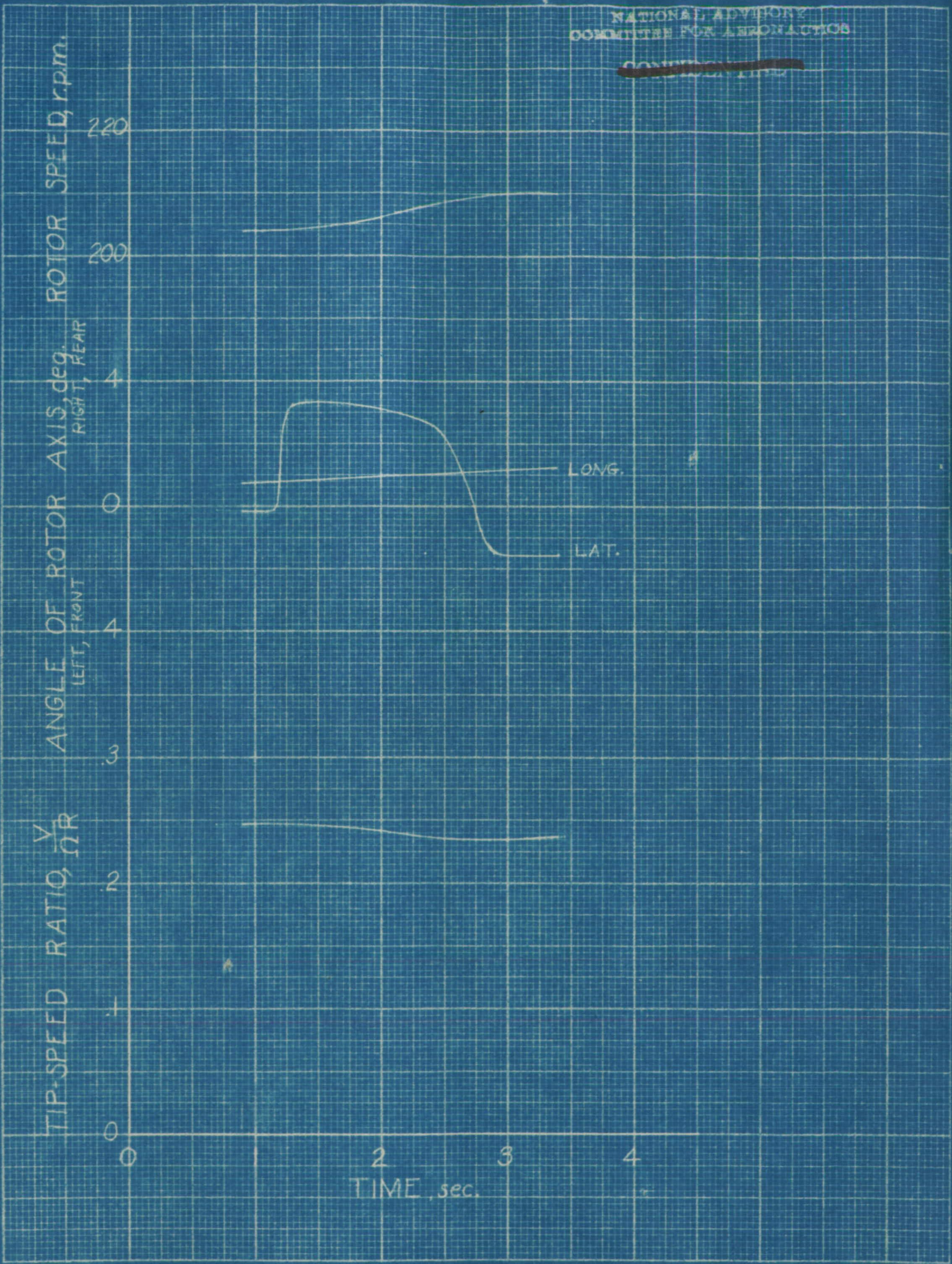

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Figure 10a.- Time history of right bank at 70 m.p.h. YG-1B autogiro with tapered blades.

7-1
Fig 10b

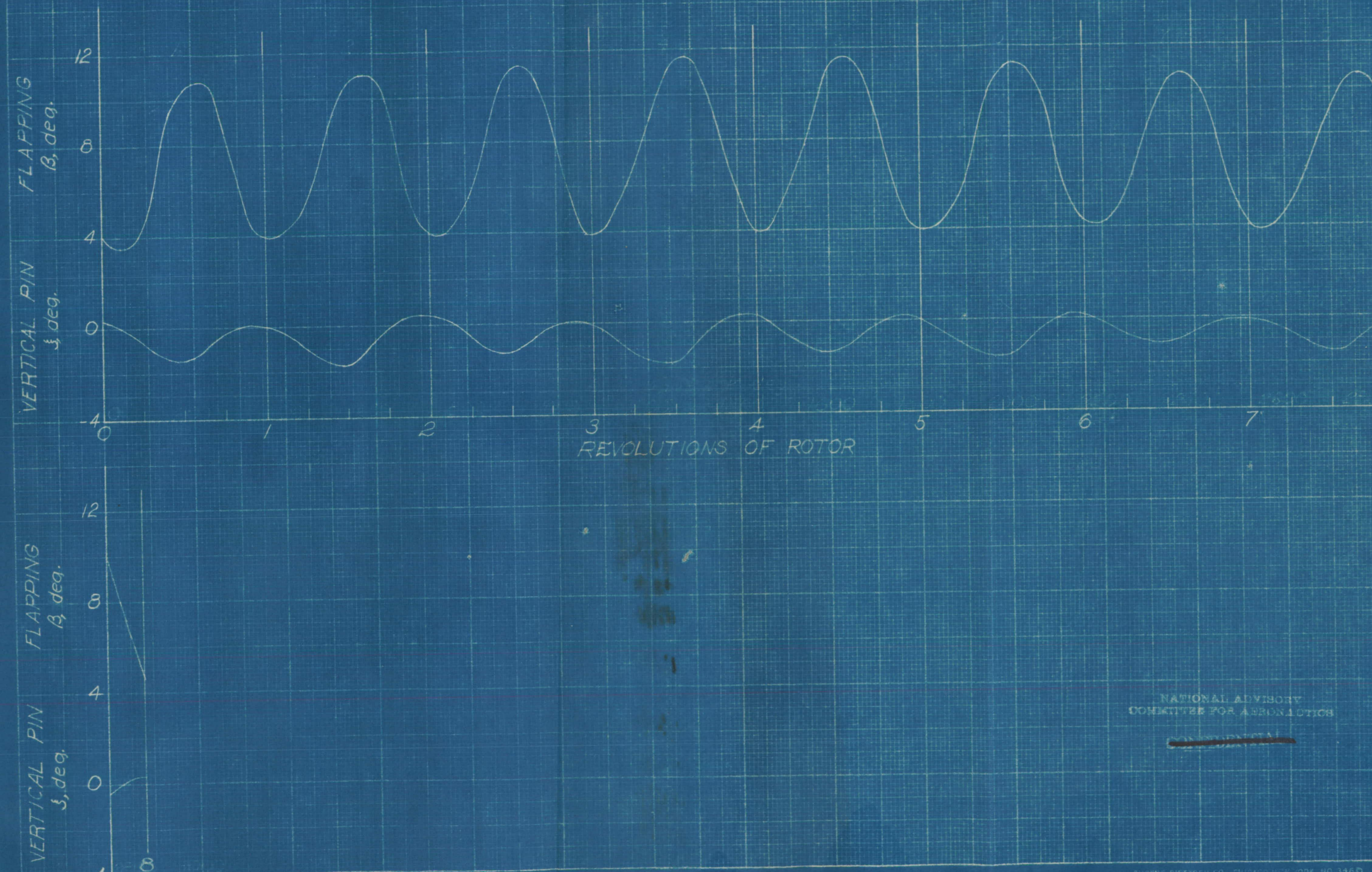

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Figure 10b.- Time history of right bank at 70 m.p.h. YG-1B autogiro with tapered blades.

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8-3
Fig 11a

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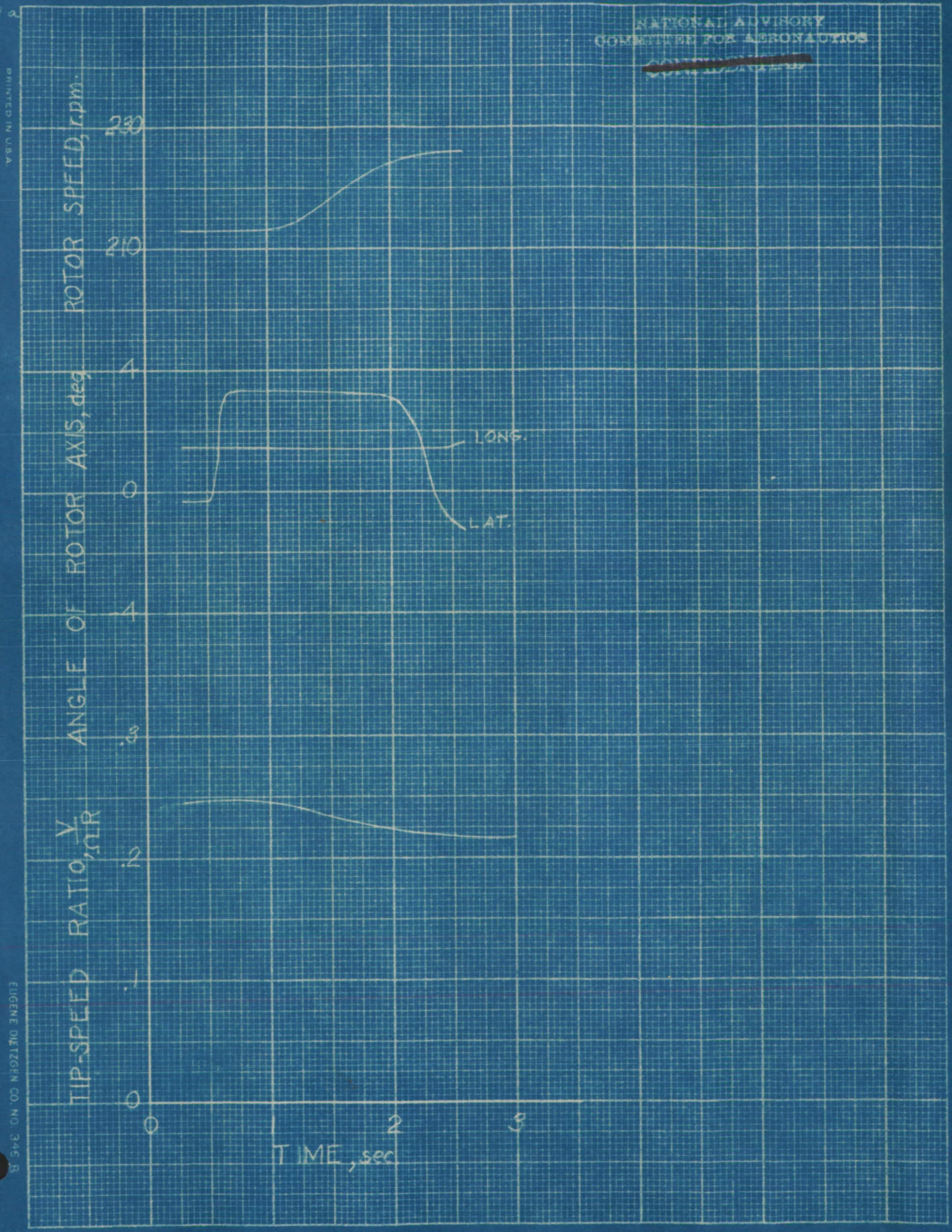

Figure 11a.- Time history of right bank at 70 m.p.h. YG-1B autogiro with tapered blades.

8-3
Fig 11b

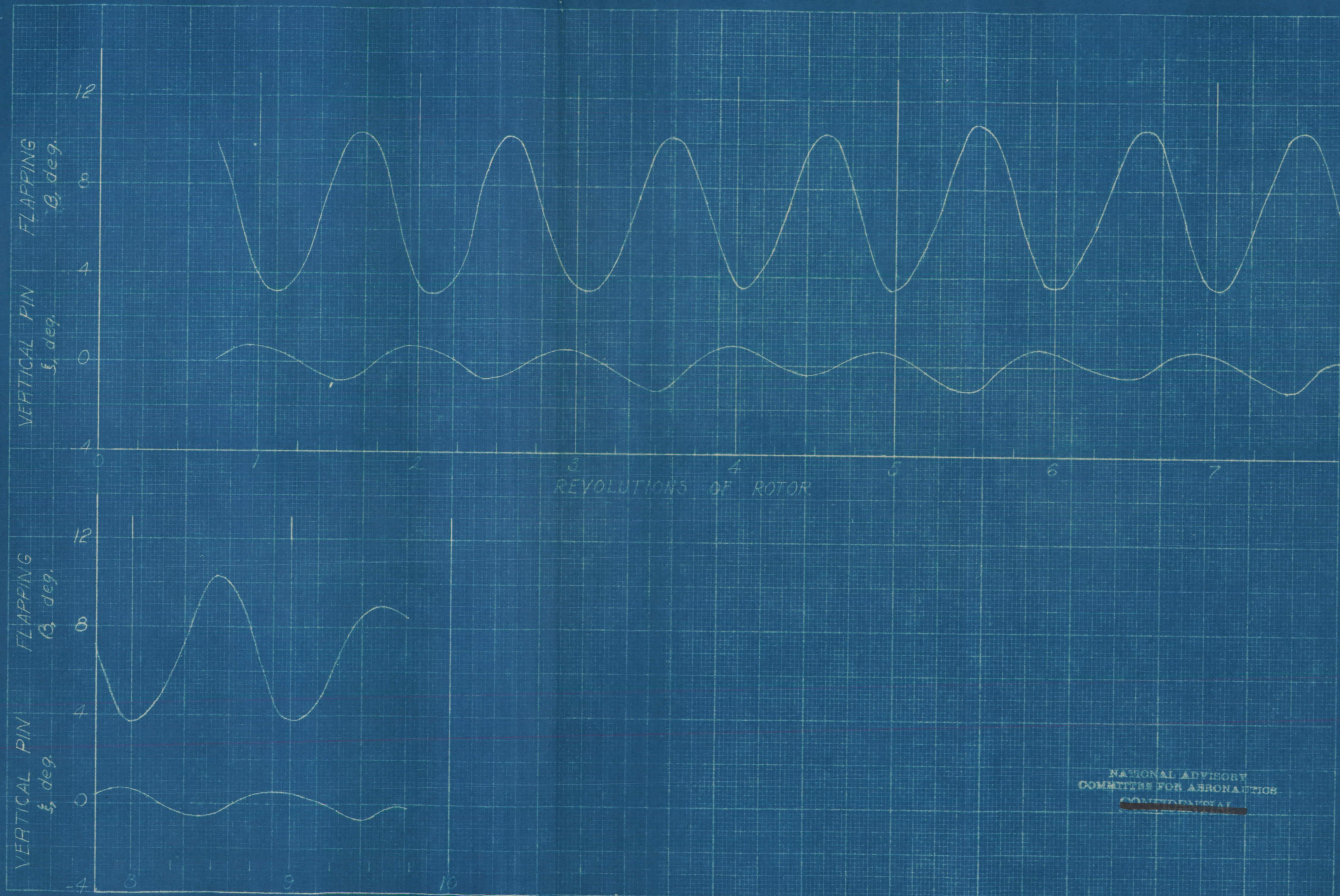

Figure 11b.- Time history of right bank at 70 m.p.h. YG-1B autogiro with tapered blades.

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7-2
Fig 12a

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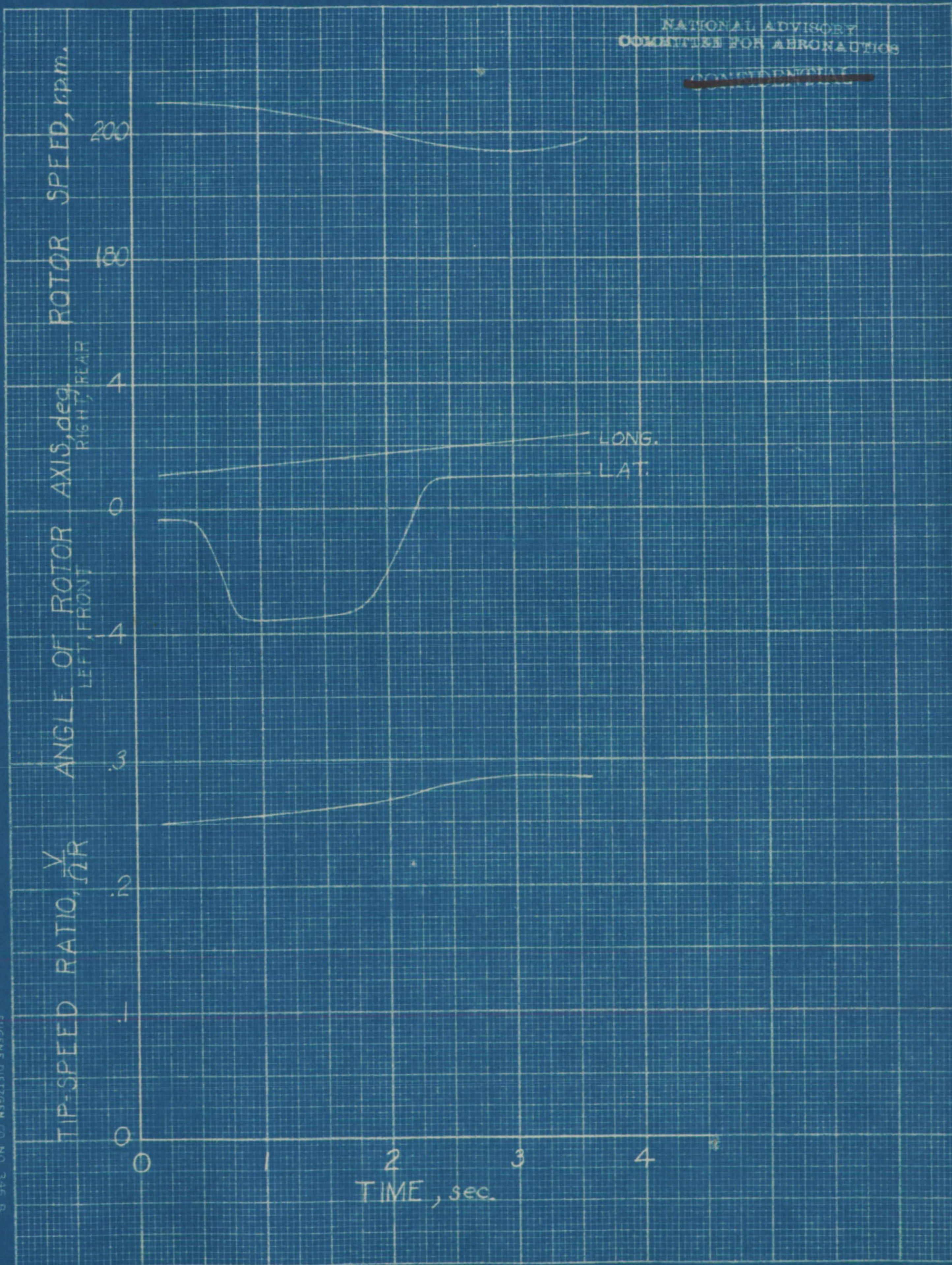

Figure 12a.- Time history of left bank at 70 m.p.h. YG-1B autogiro with tapered blades.

7-2
Fig 12 b

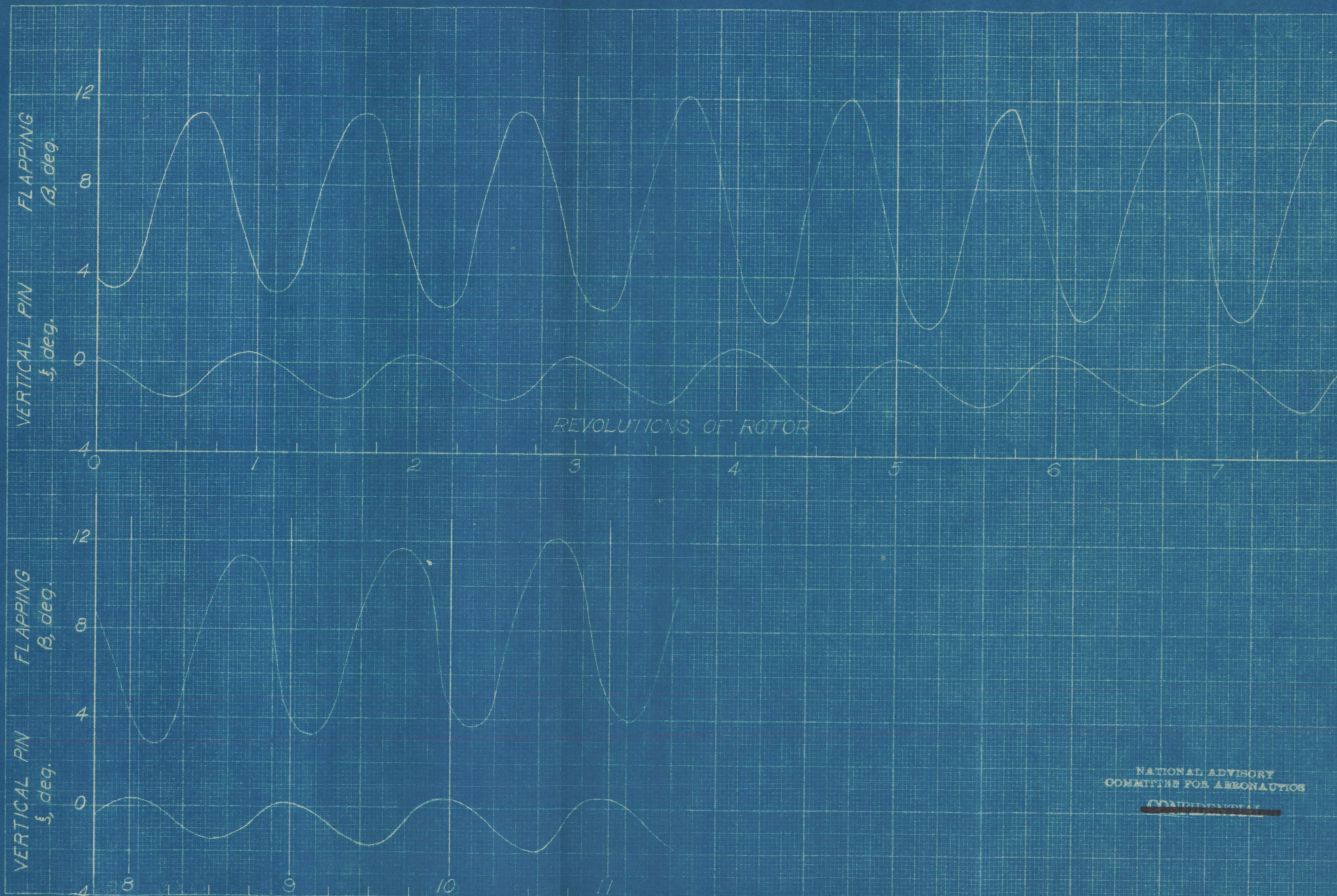

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Figure 12b.- Time history of left bank at 70 m.p.h. YG-1B autogiro with tapered blades.

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8-2
Fig 13 a

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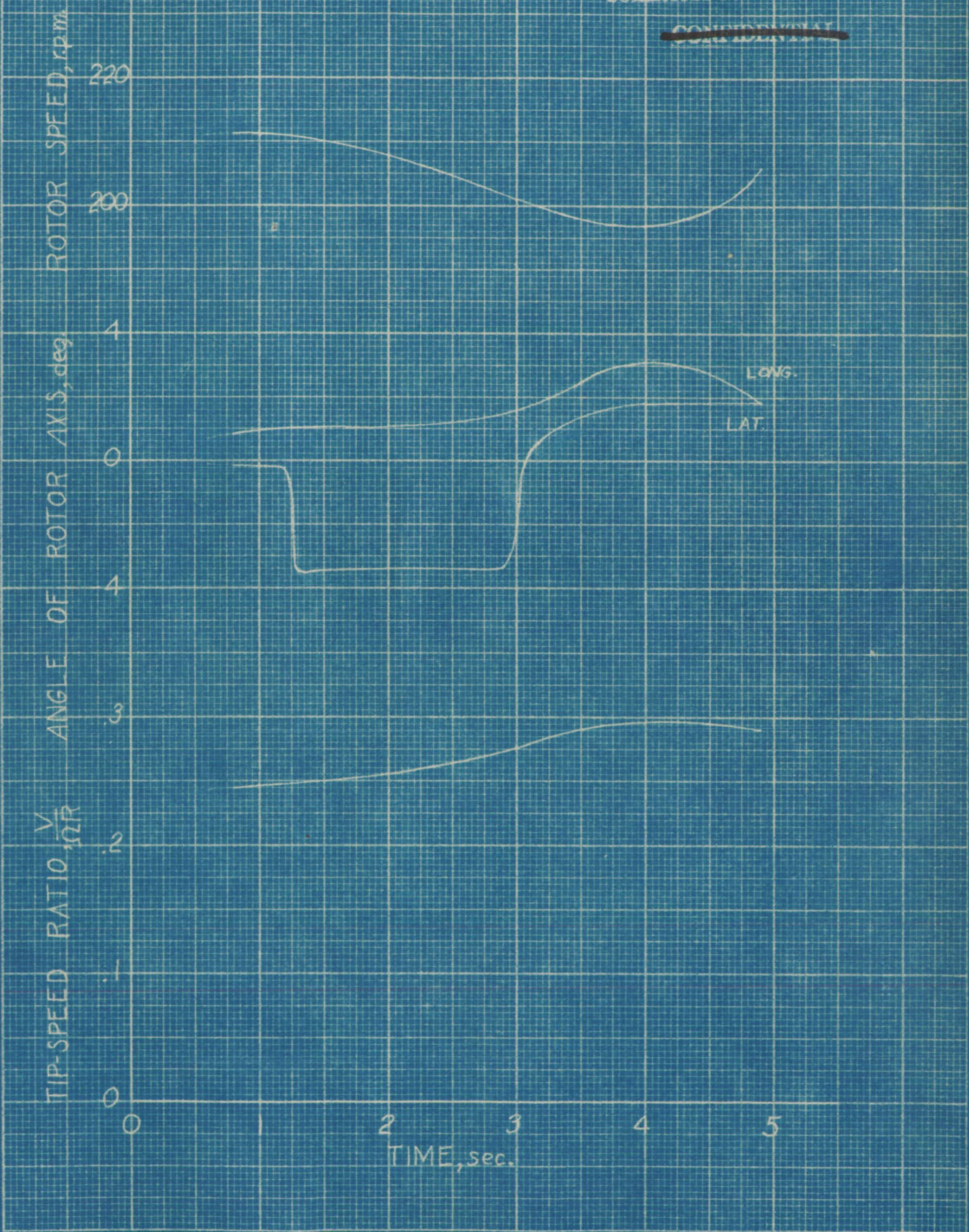

Figure 13a.- Time history of left bank at 70 m.p.h. YG-1B autogiro with tapered blades.

8-2
Fig. 13b

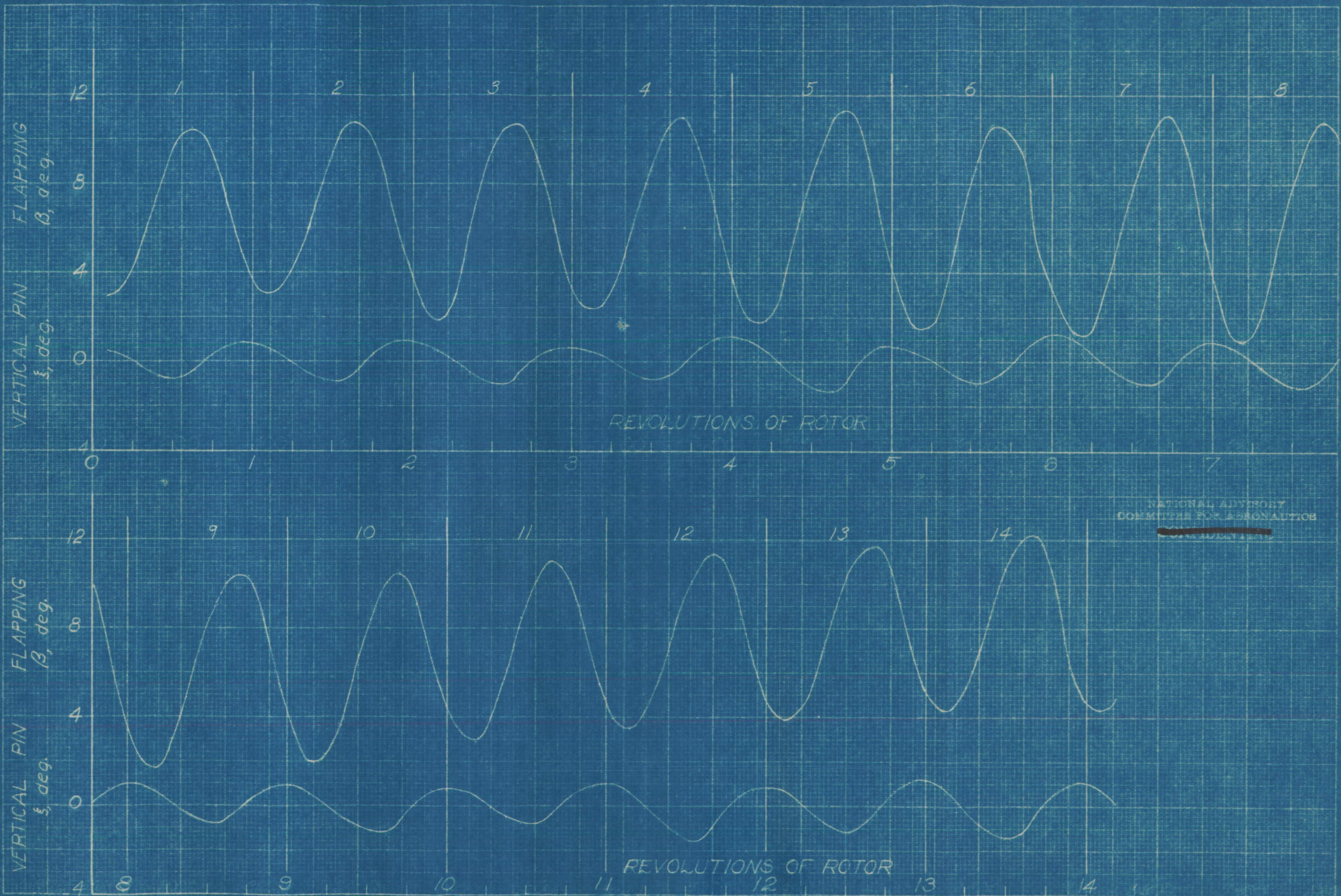

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Figure 13b.- Time history of left bank at 70 m.p.h. YG-1B autogiro with tapered blades.

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7-7
Fig 14a

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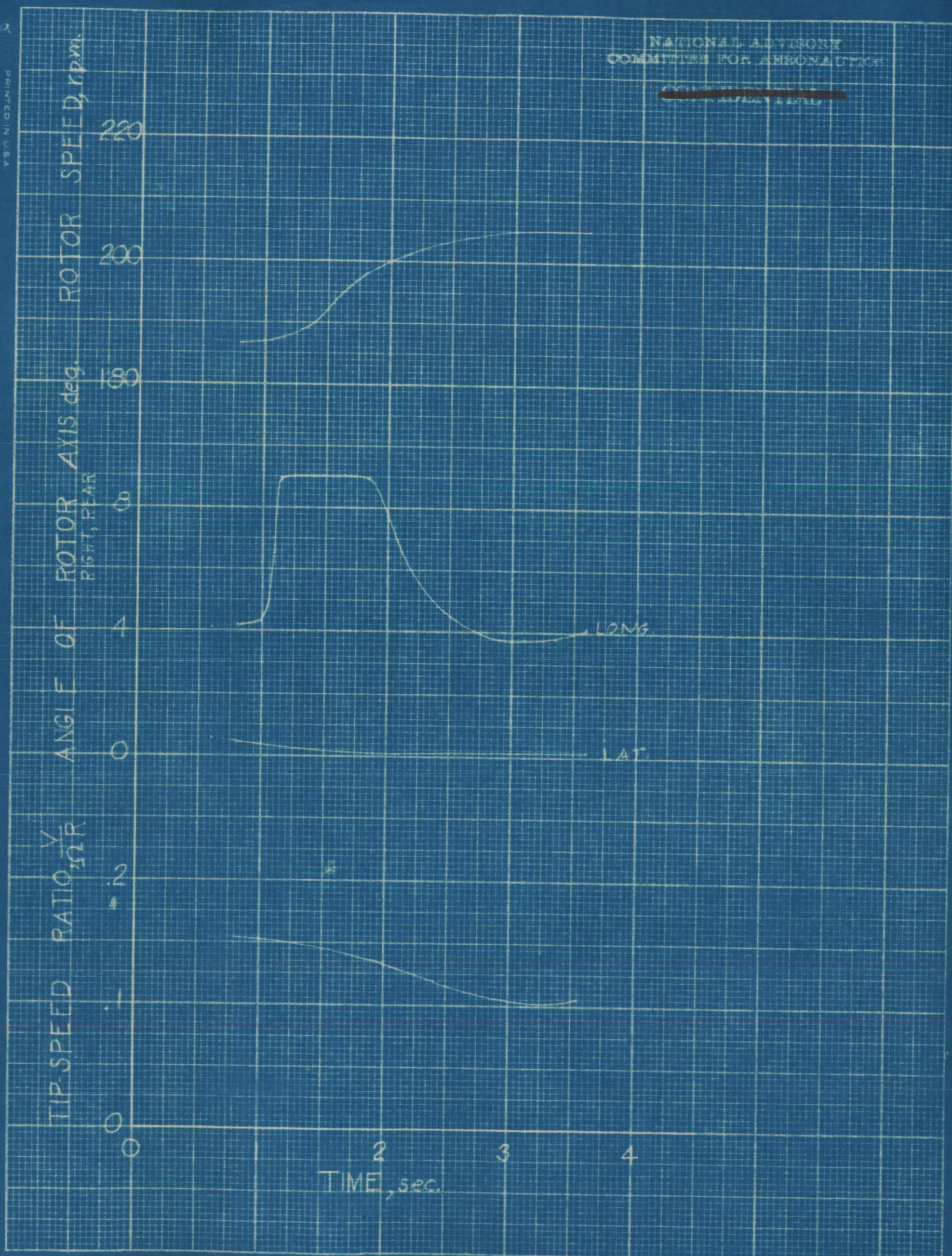

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Figure 14a.- Time history of pull-up at 40 m.p.h. YG-1B autogiro with tapered blades.

7-7
Fig 14b

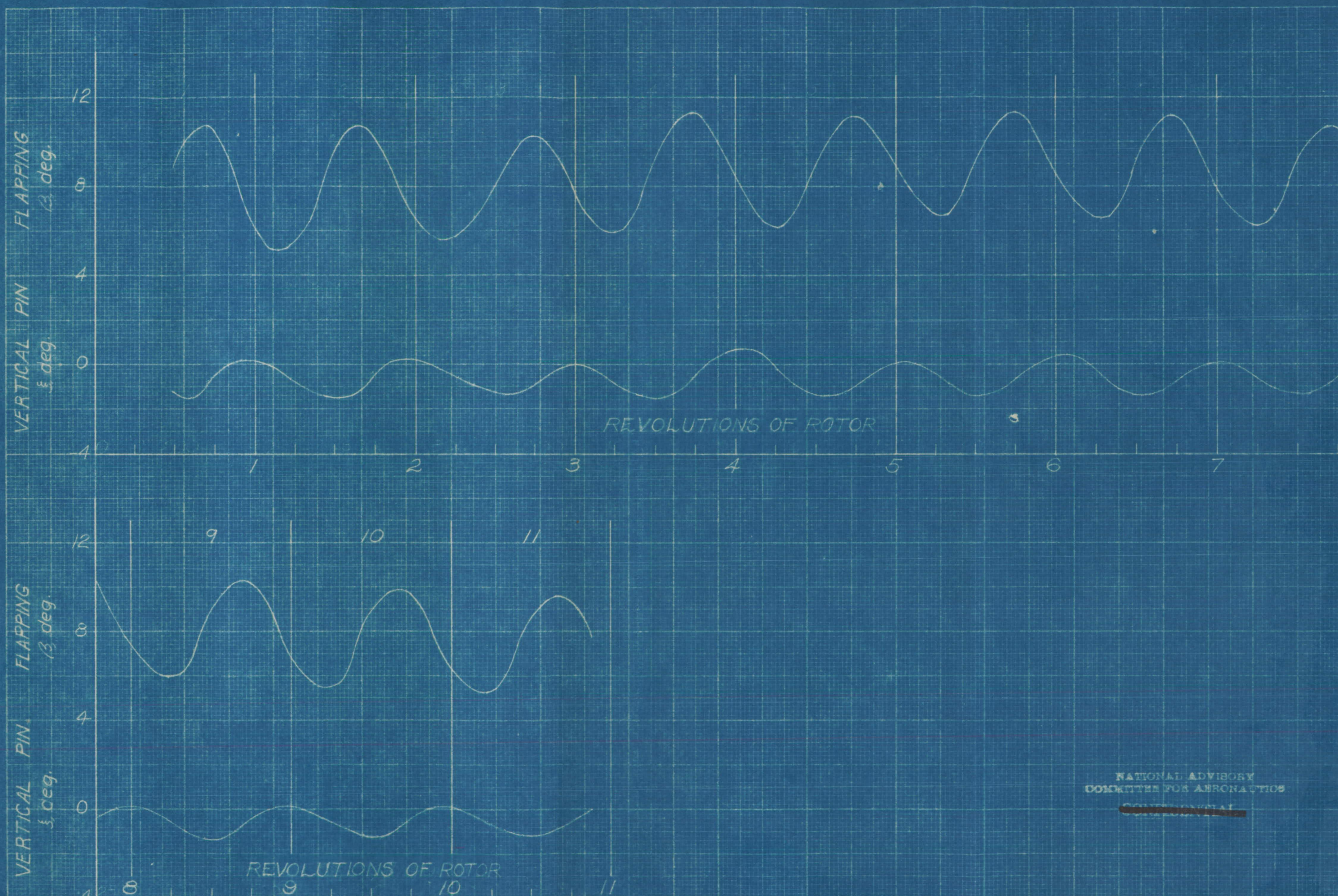

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Figure 14b.- Time history of pull-up at 40 m.p.h. YG-1B autogiro with tapered blades.

7-4
FIG 15a

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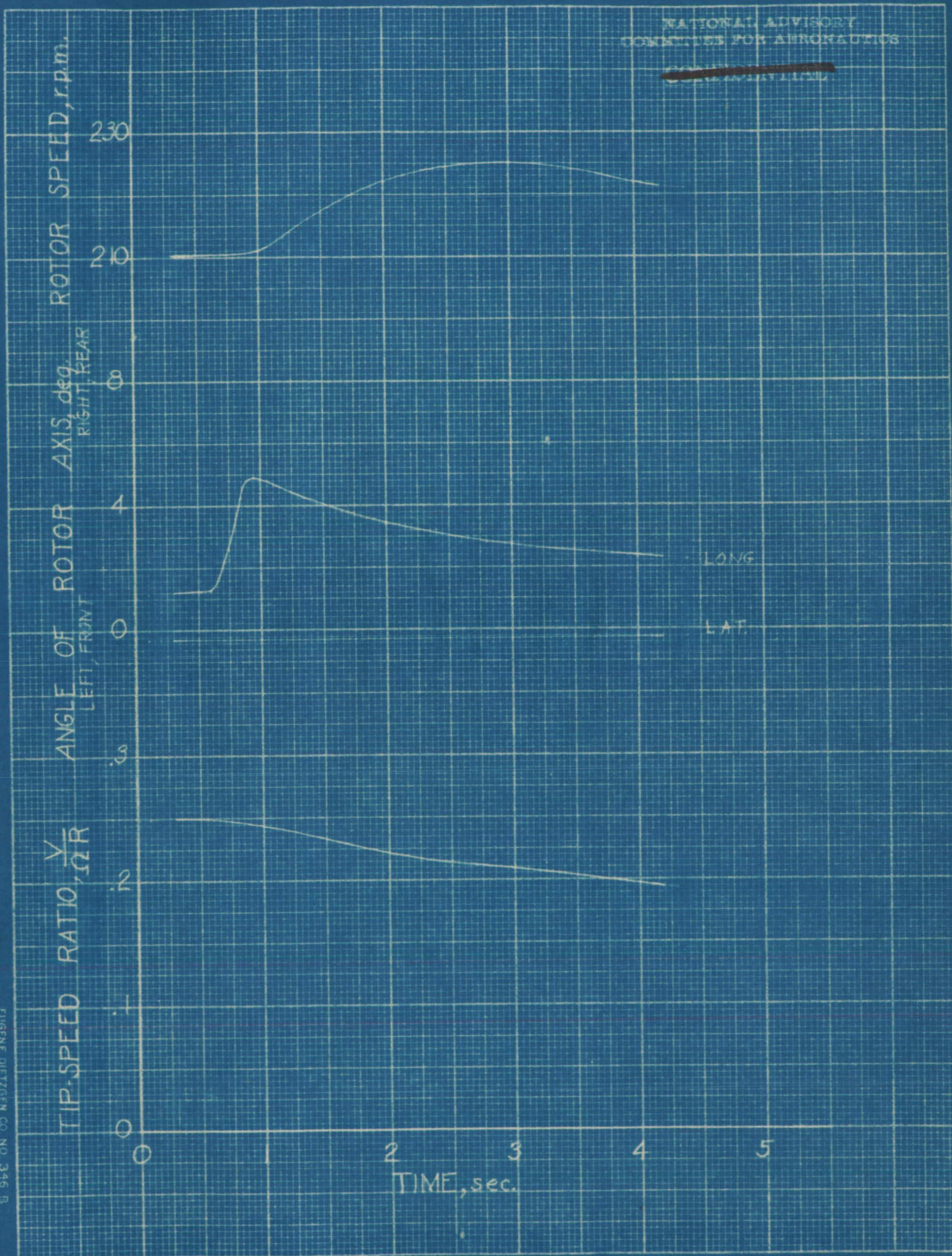

Figure 15a.- Time history of pull-up at 70 m.p.h. YG-1B autogiro with tapered blades.

7-4
Fig. 15b

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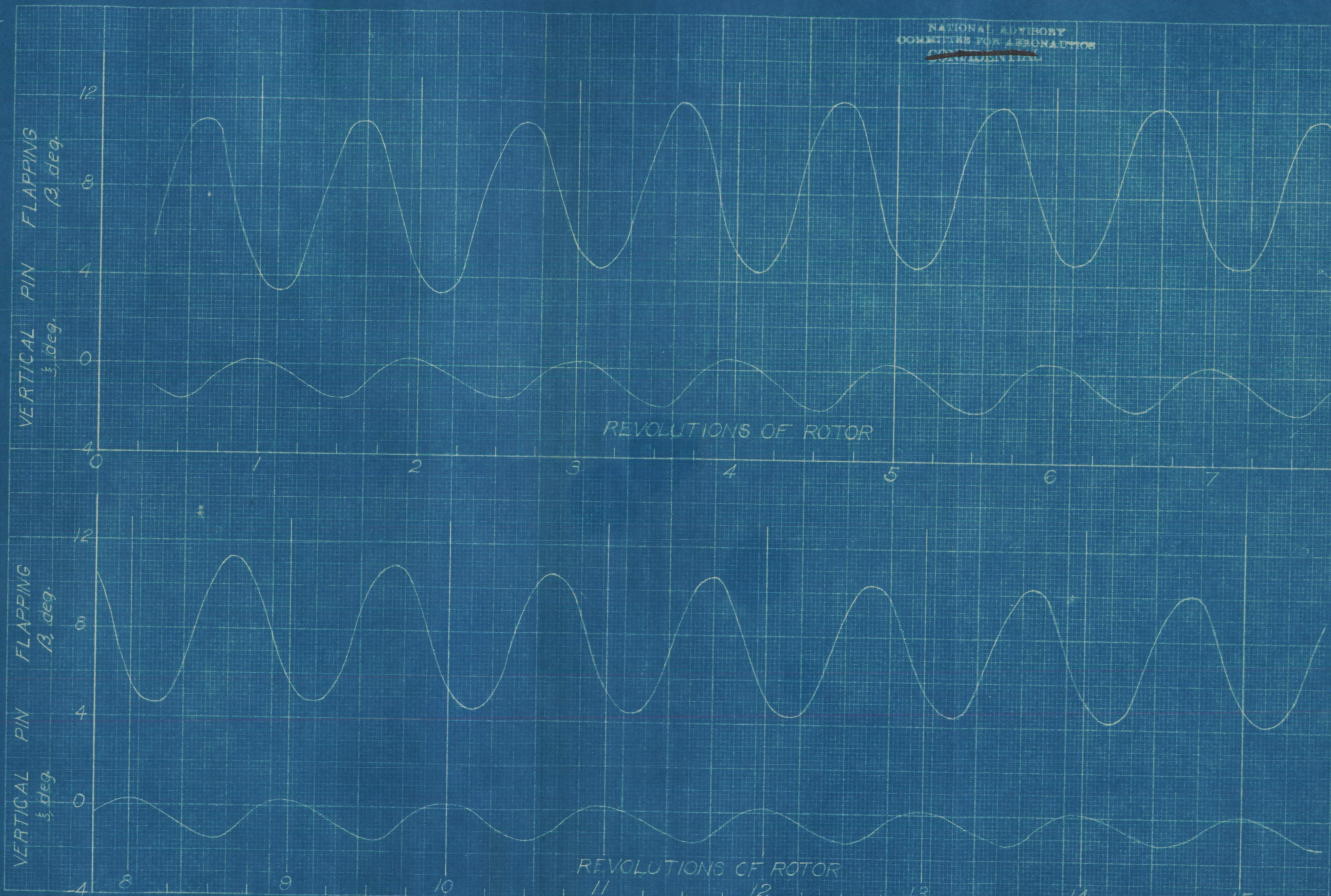

Figure 15b.- Time history of pull-up at 70 m.p.h. ...

T-5
FIG 16a

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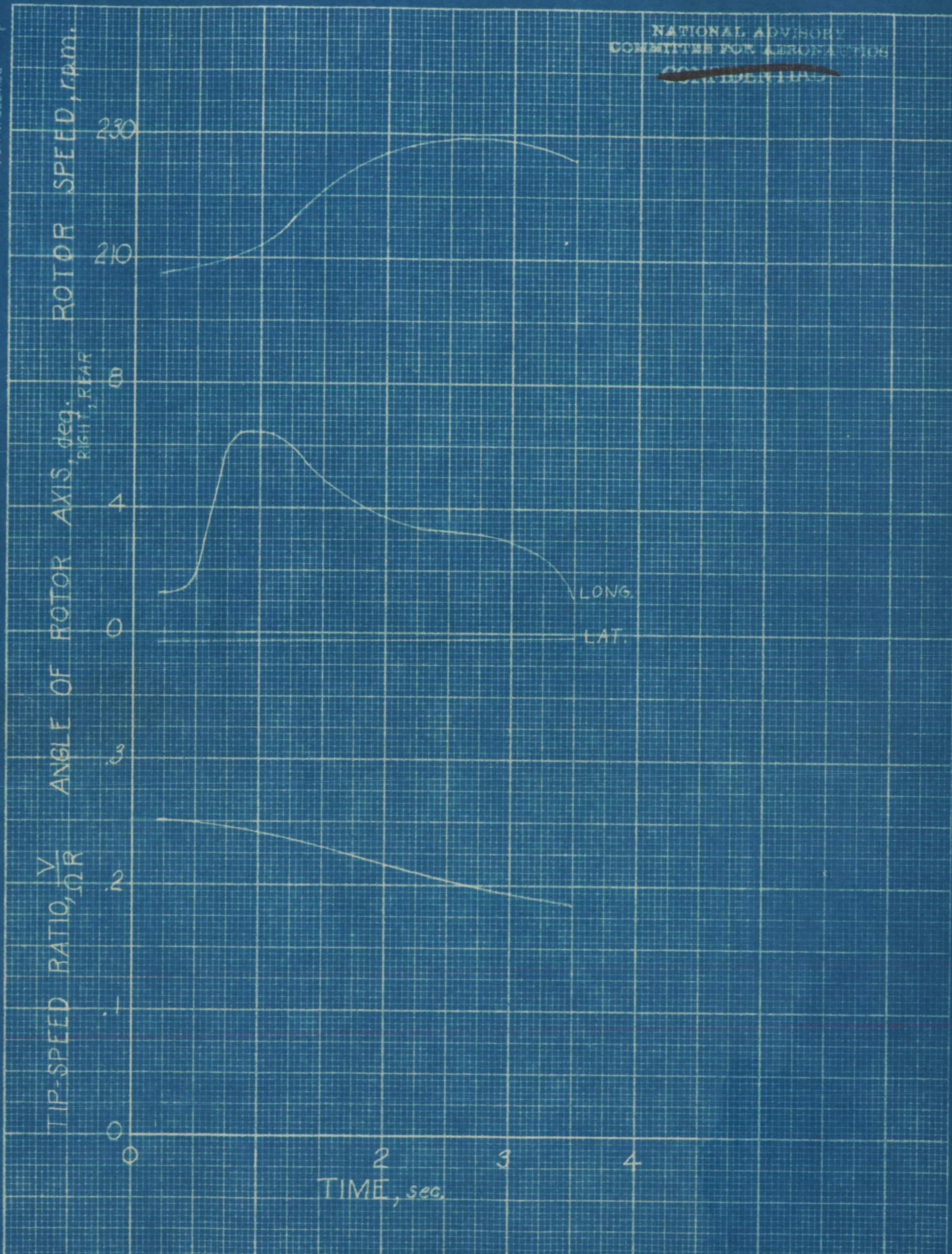

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Figure 16a.- Time history of pull-up at 70 m.p.h. YG-1B autogiro with tapered blades.

7-5
Fig 16b

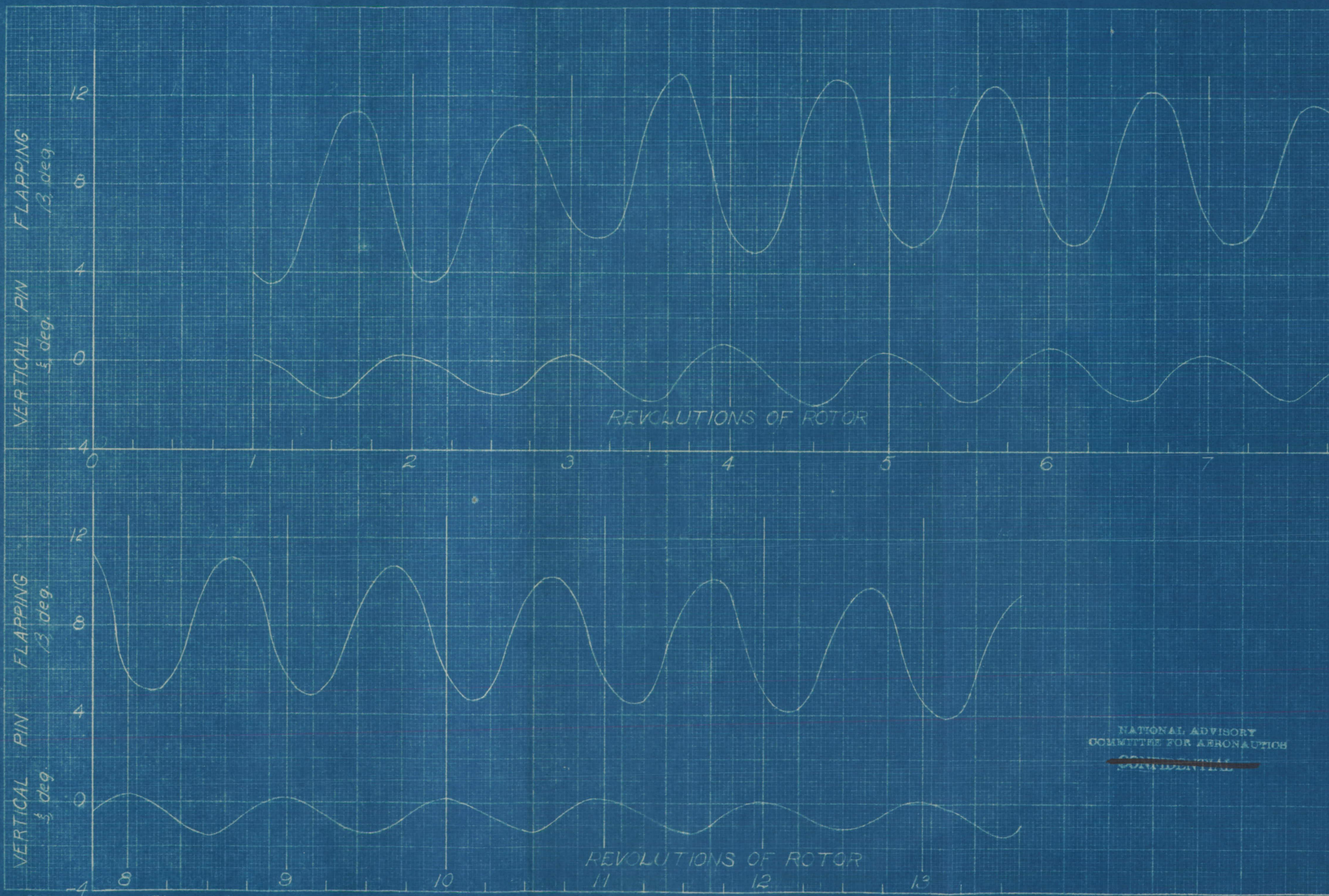

Figure 16b.- Time history of pull-up at 70 m.p.h. YG-1B autogiro with tapered blades.

Fig. 17a.

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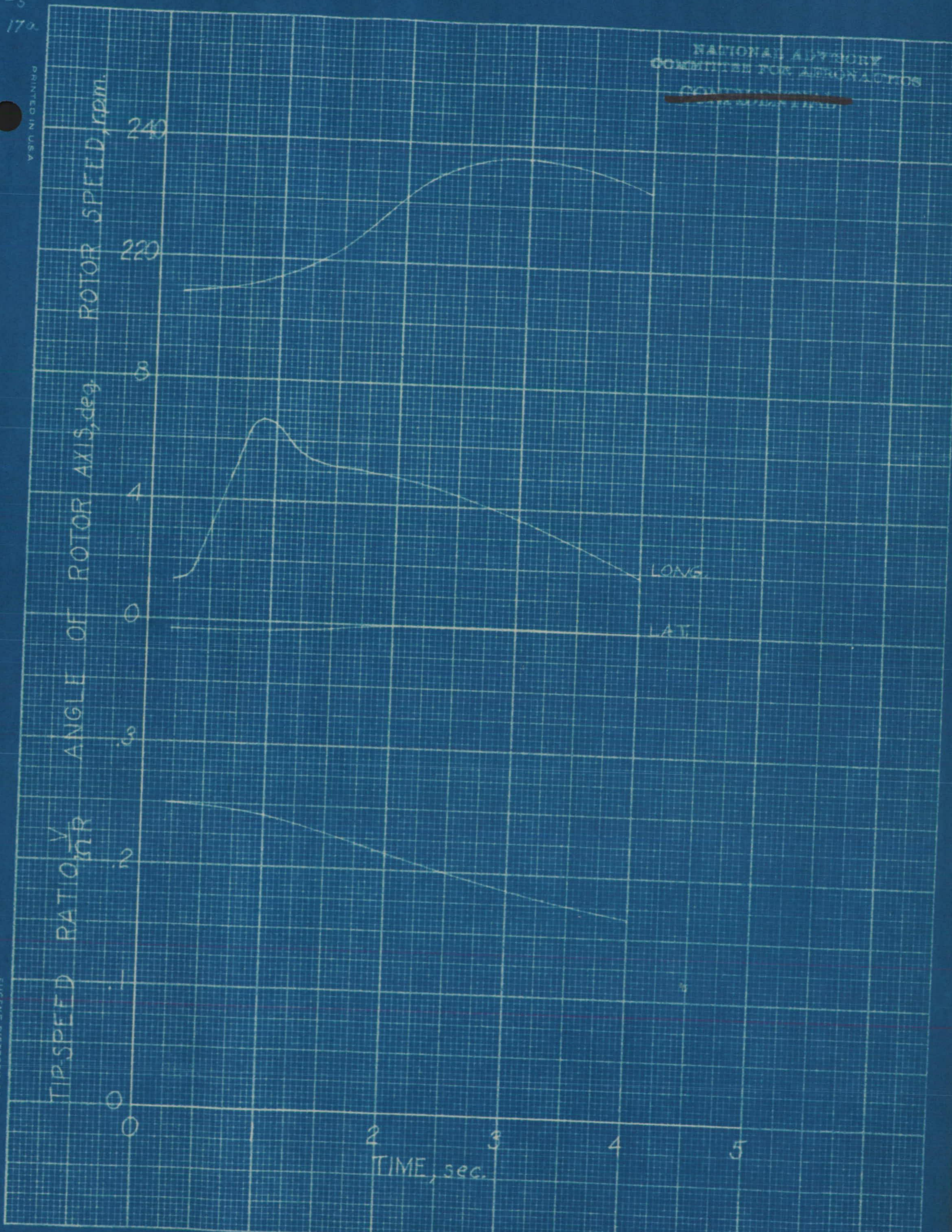

Figure 17a.- Time history of pull-up at 70 m.p.h. YG-1B autogiro with tapered blades.

8-5
FIG 17b

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Figure 17b.- Time history of pull-up at 70 m.p.h. YG-1B autogiro with tapered blades.

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8-4
FIG 18a

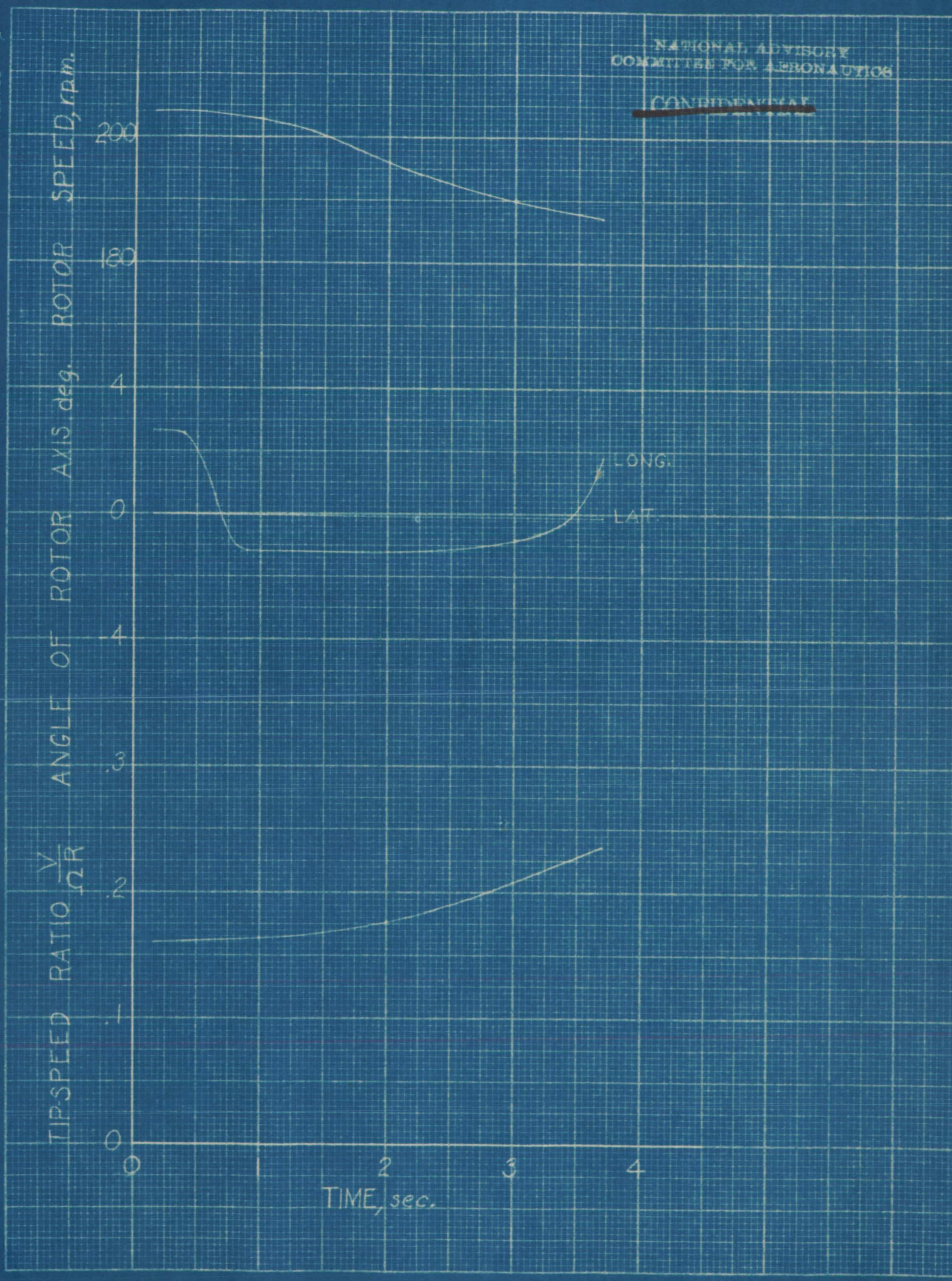

Figure 18a.- Time history of push-down at 45 m.p.h. YG-1B autogiro with tapered blades.

E-4
FIG 18 b

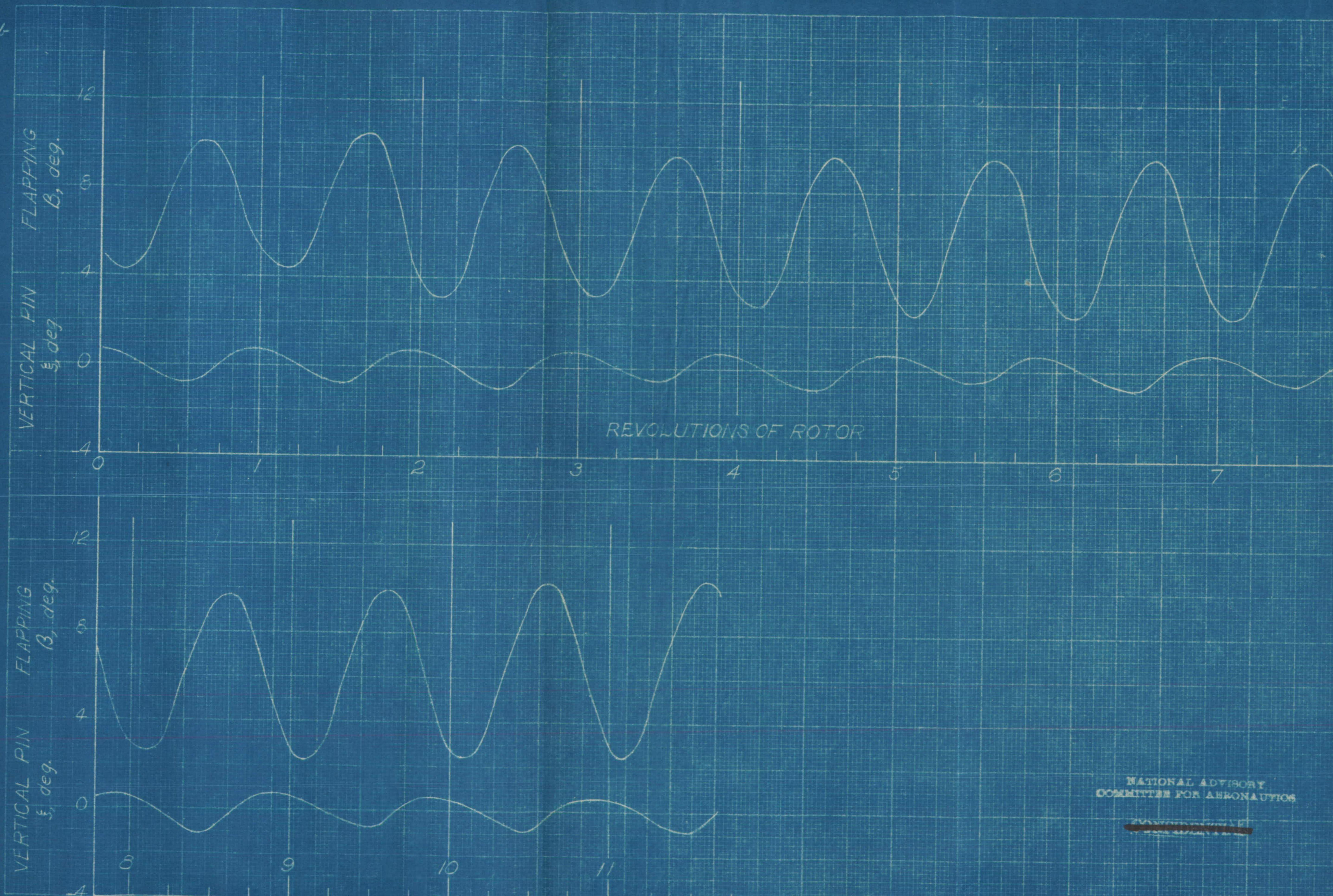

Figure 18b.- Time history of push-down at 45 m.p.h. YG-1B autogiro with tapered blades.

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7-3
Fig 19a

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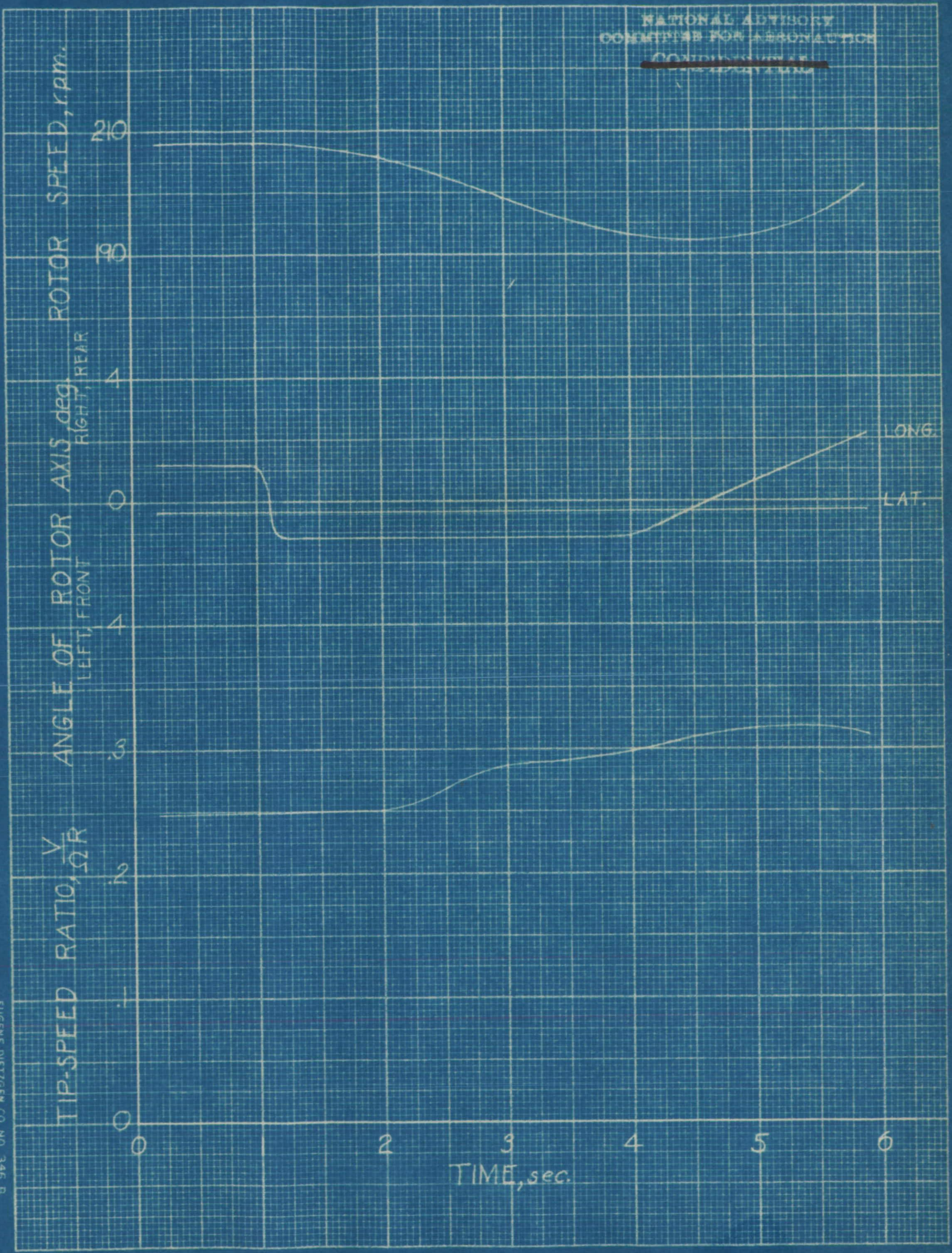

Figure 19a.- Time history of push-down at 70 m.p.h. YG-1B autogiro with tapered blades.

7-3
Fig 19b

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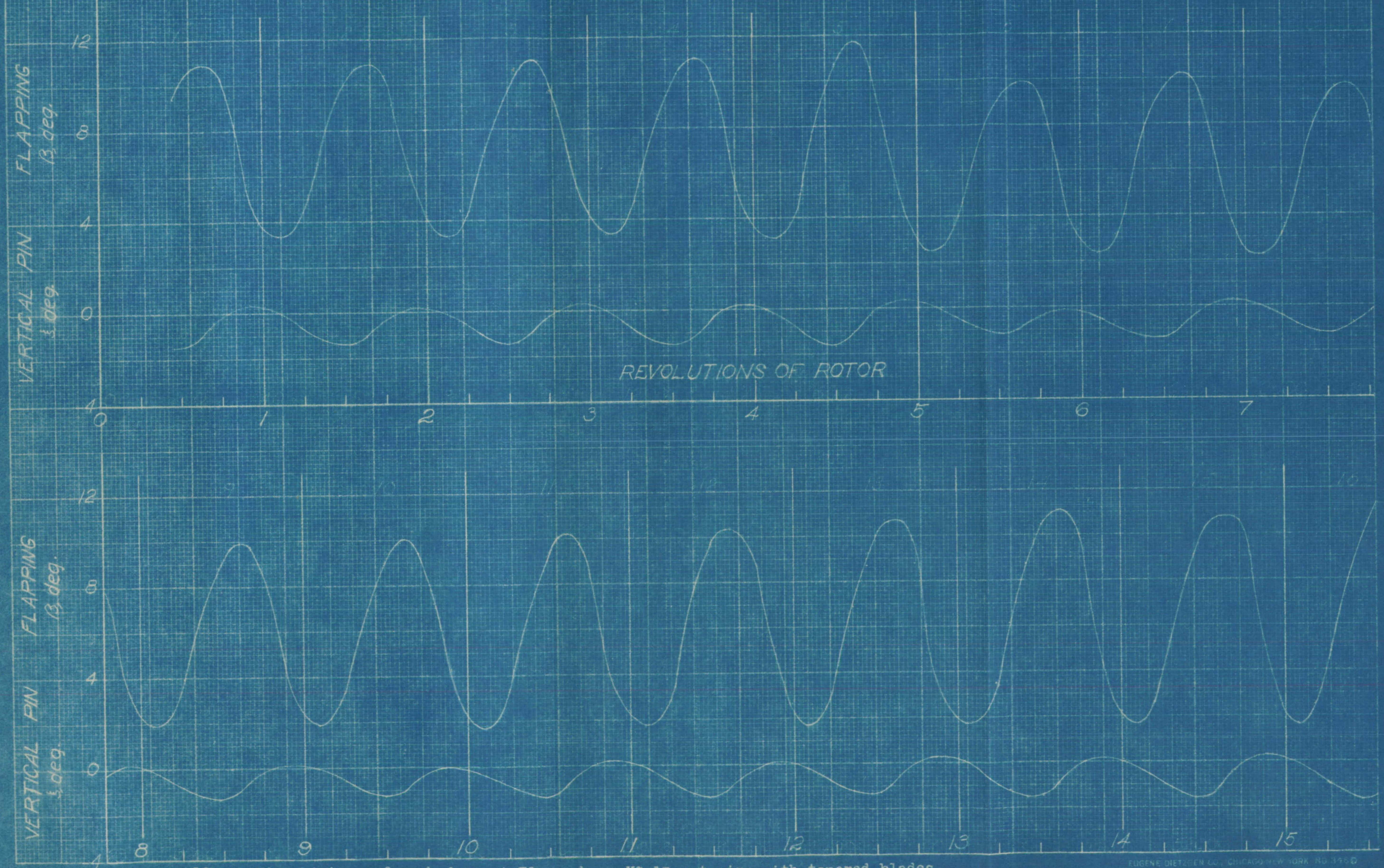

Figure 19b.- Time history of push-down at 70 m.p.h. YG-1B autogiro with tapered blades.

7-3
Fig 19c

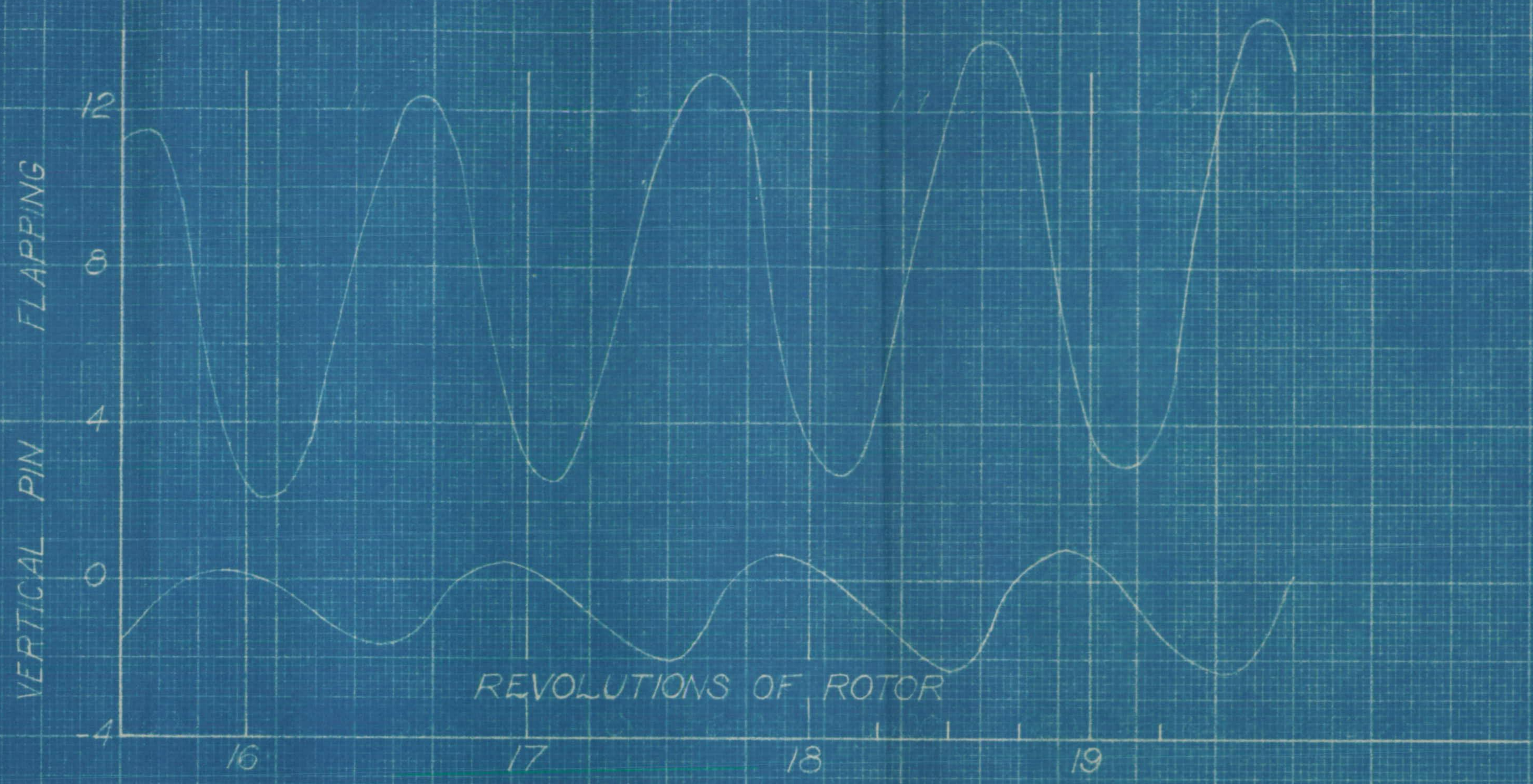

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Figure 19c.- Time history of push-down at 70 m.p.h. YG-1B autogiro with tapered blades.

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8-6
Fig. 20a

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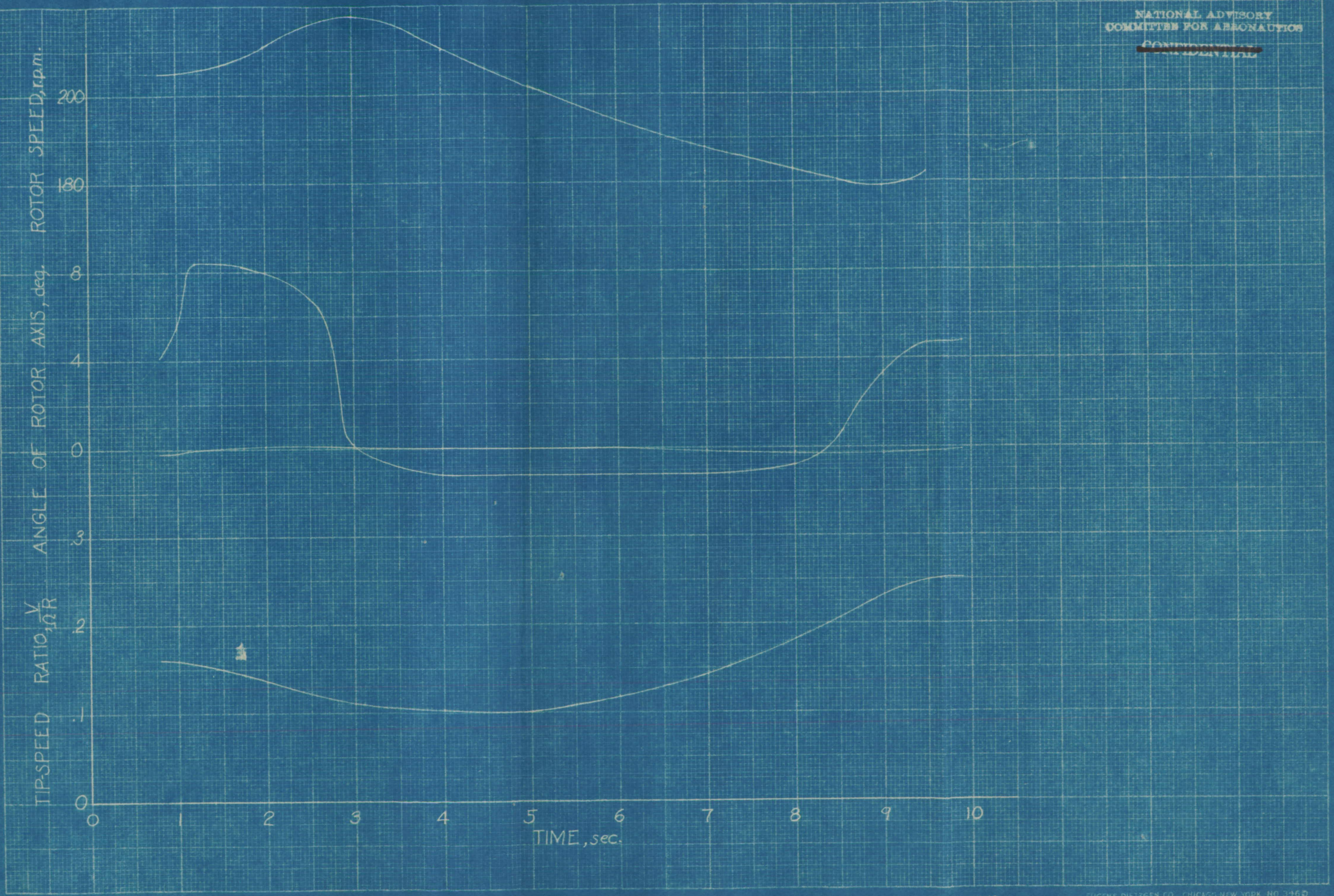

Figure 20a.- Time history of pull-up at 40 m.p.h. followed by a push-down. YG-1B autogiro with tapered blades.

8-6
FIG 20b

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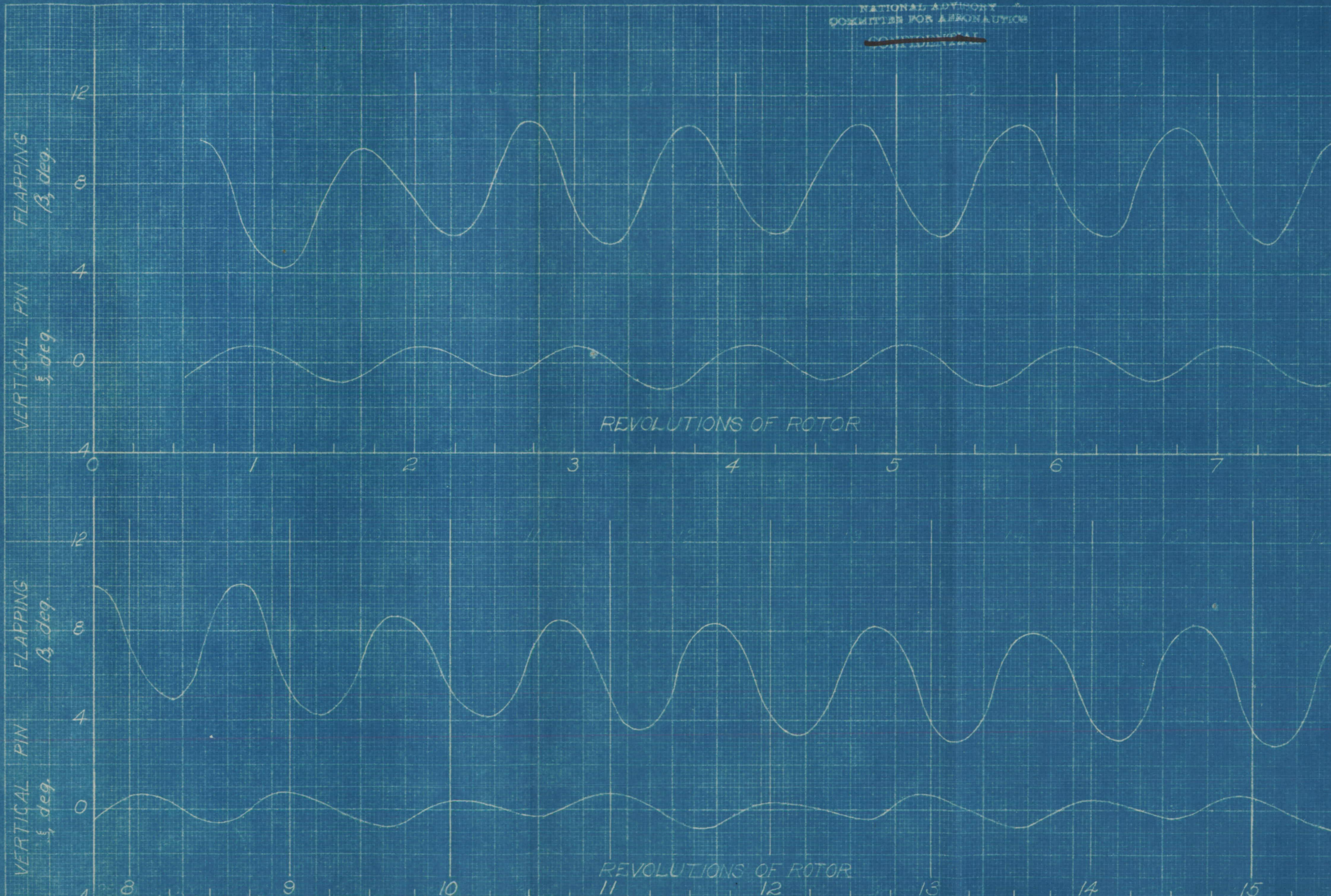

Figure 20b.- Time history of pull-up at 40 m.p.h. followed by a push-down. YG-1B autogiro
with tapered

8-C
Fig 20 C

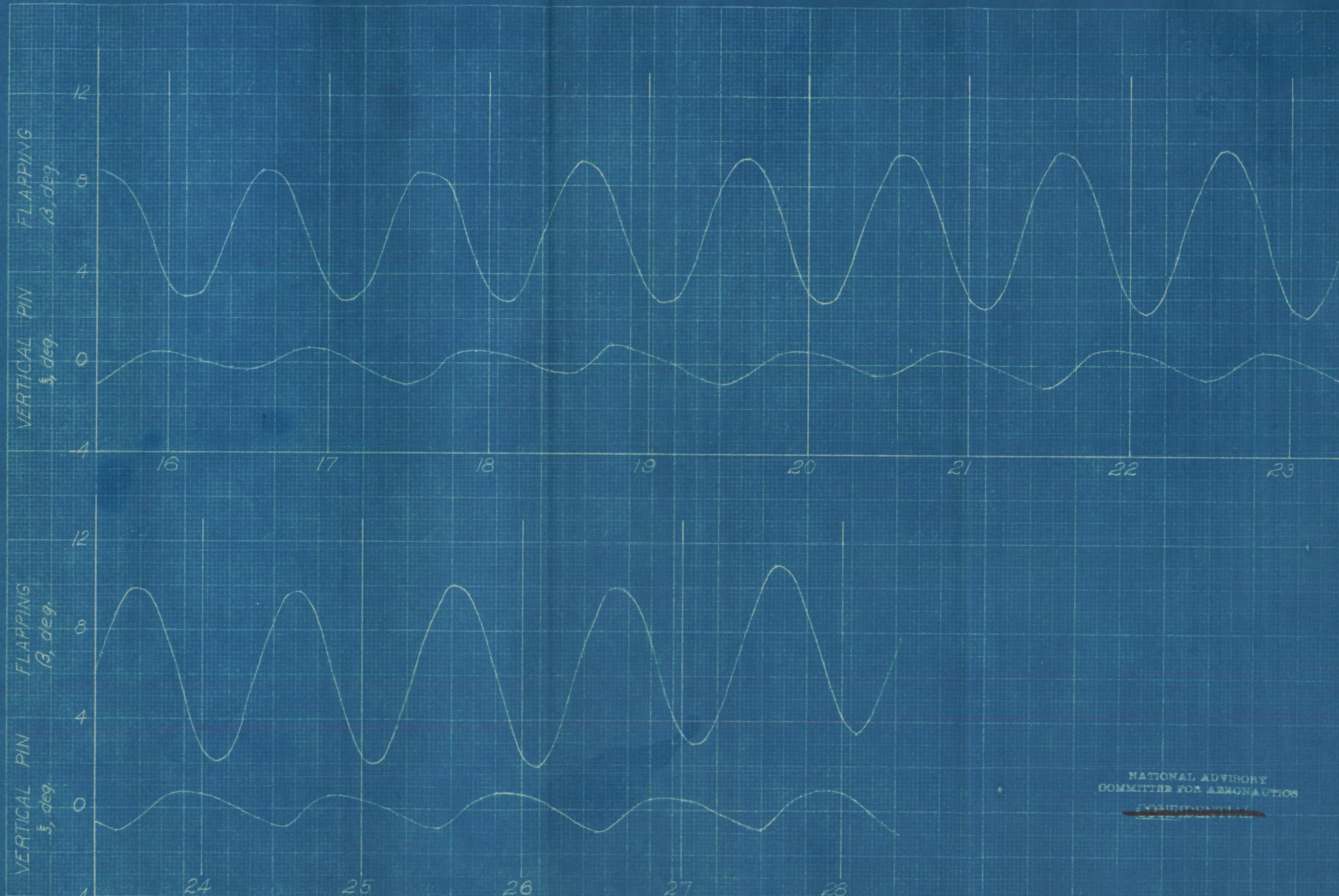

Figure 20c.- Time history of pull-up at 40 m.p.h. followed by a push-down. YG-1B autogiro

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FIG21

[redacted]

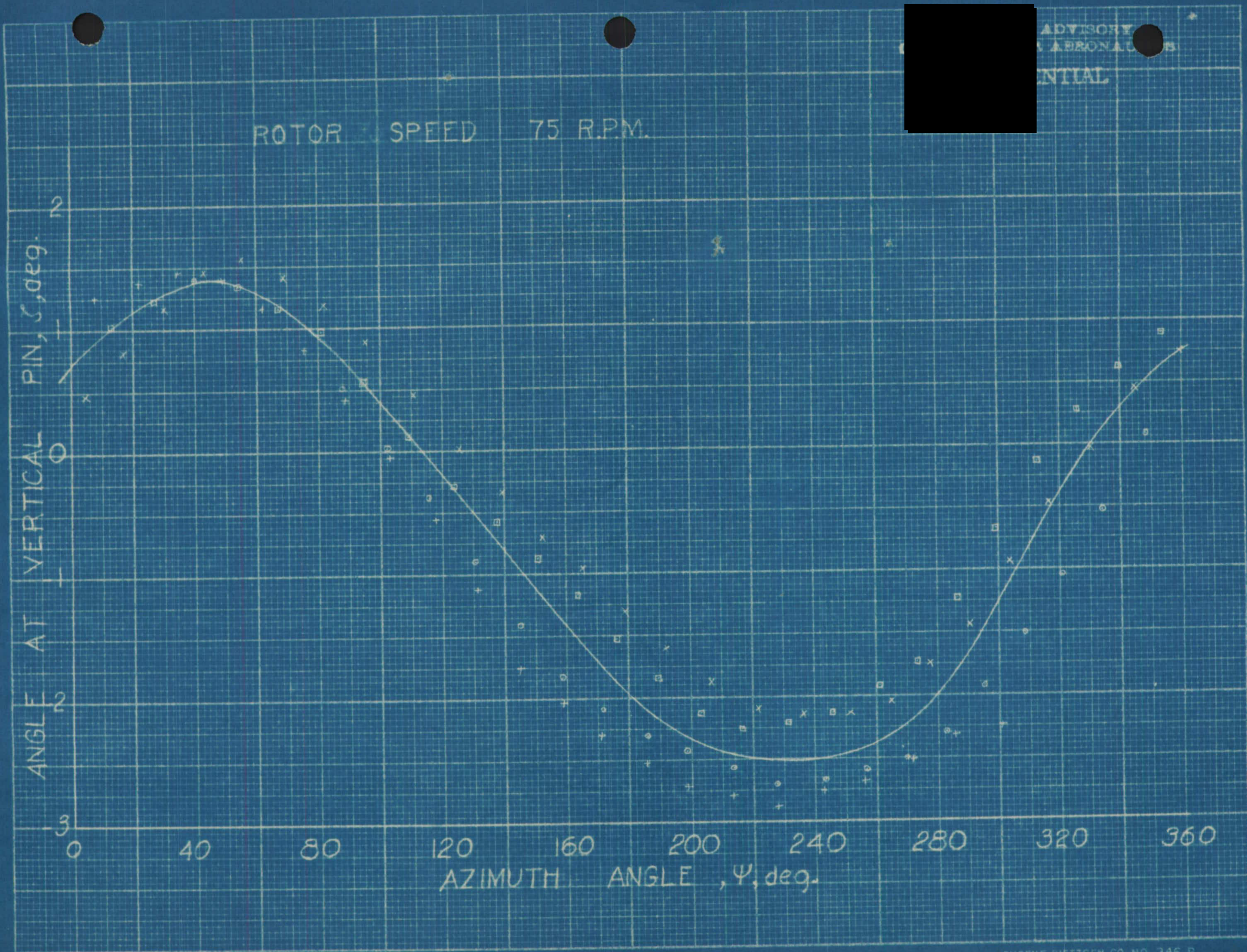

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Figure 21.- Typical motion about vertical pin with the autogiro on the ground and the rotor being driven steadily by the engine. YG-1B autogiro with tapered blades.

FIG 22

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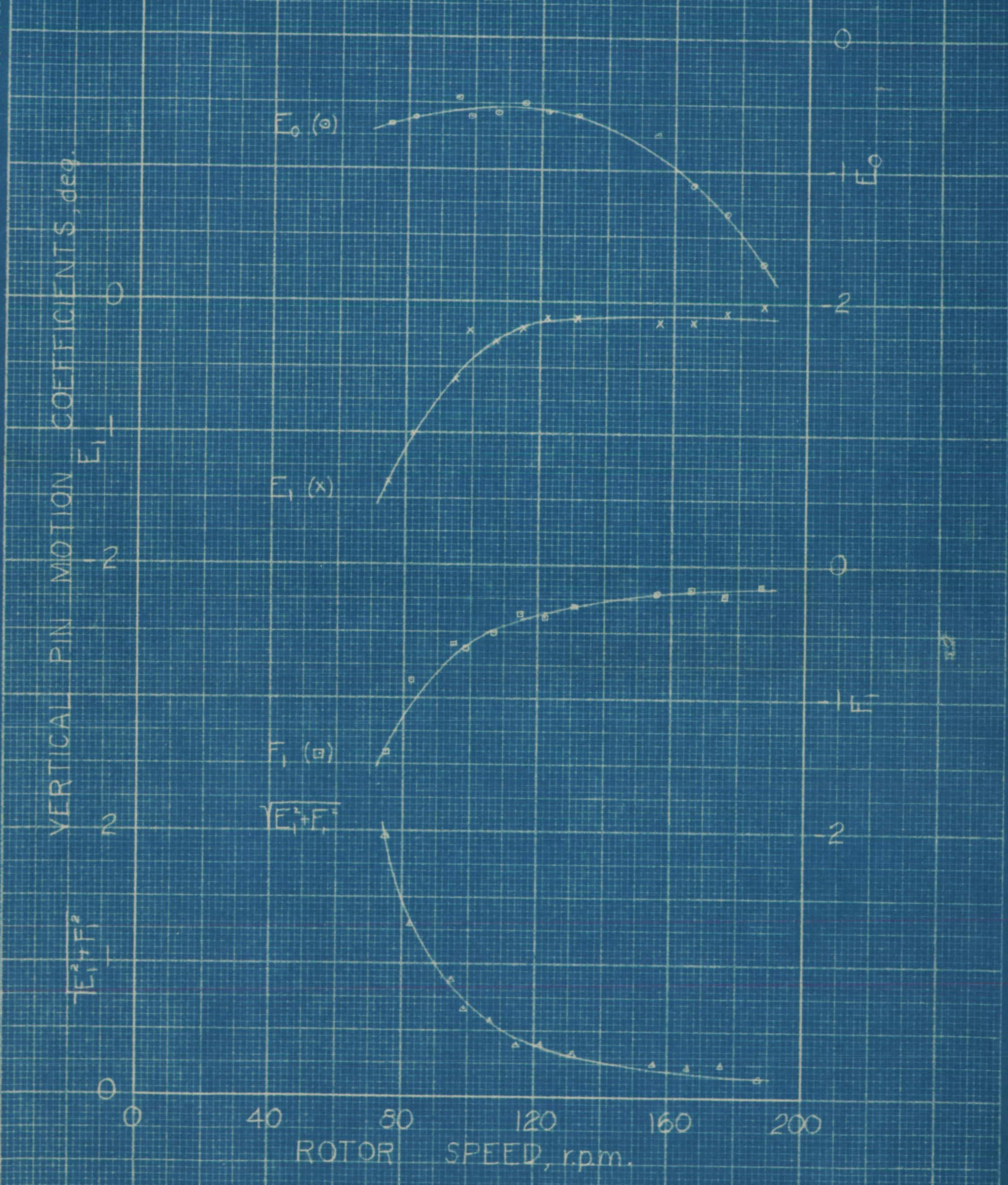

Figure 22.- Coefficients of motion about the vertical pin with the autogiro on the ground and the rotor being driven steadily by the engine. YG-1B autogiro with tapered blades.

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